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Impact of Science and Technology on Regional Development

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U.S. DEPARTMENT OF COMMERCE
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Impact of Science and Technology on Regional Development

prepared by

Midwest Research Institute

Bruce W. Macy, James M. Bednar, Robert E. Roberts

for the

U.S. DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary

Ross D. Davis, Assistant Secretary
for Economic Development

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I. INTRODUCTION

Background

Since the advent of large scale research and development in World War II and its expansion in the 1950's and 60's, the role of science and technology in economic development has been a topic of wide interest, much discussion and some study. Interest in the role of technological advance has focused on the national level, and to some extent on development of emerging nations abroad. More recently there has been growing concern at the regional level within this country regarding the role of science and technology in regional development. This interest has been stimulated and shaped by the emergence of a few science-industry-government complexes around the country. The dramatic impact of these complexes on their local economies, both in terms of growth and structure, together with the seemingly windfall nature of their location, has led to a popular assignment of almost mystical properties to the power of science and technology in regional development. City after city and area after area have attempted to enhance their development via these newly articulated forces. Some have been successful, most have not. In many instances the reasons for success or failure remain obscure. In view of the foregoing, this study was undertaken to review the available knowledge on the subject and assemble this body of basic information into one document.

Intent

The study was undertaken under the auspices of the Office of Regional Development Planning with the specific intention of providing background information to the Regional Commissions established under Title V of the Public Works and Economic Development Act of 1965. In carrying out their assigned role of fostering the development of their regions, the Regional Commissions are fundamentally and ultimately concerned with improved job opportunities and higher income levels. Accordingly, we have emphasized those aspects of the impact of science and technology judged most relevant to the Commissions' needs. Other aspects of the subject of considerable academic interest but peripheral to the Commissions' interests were not developed in depth.

Scope

The study was a state-of-the-art review, i.e., a survey to identify what is known about the impact of science and technology in regional development and to identify those facets of the subject area about which our knowledge appears limited. As such, the investigations were confined to a review of the literature and an examination and description of organizational forms which have been employed to stimulate regional science- and technology-based growth.

Research and development can influence regional development in several ways:

(1) Dollars spent for R&D conducted in a region provide a source of employment and income, which in turn have a multiplier effect on the economy;

(2) The results of R&D -- wherever conducted -- can stimulate regional growth; and

(3) The presence of R&D activity and the influence of local technical personnel often yield secondary benefits in the form of improved educational and cultural facilities.

The scope of the study was not confined to an examination of the impact of research and development, alone. The location or expansion of an R&D center in the region is of course significant in regional development. However, the direct impact of such a center is modest compared to the sweeping changes associated with new processes, products, and skill requirements which result from the general advance of science and technology. The upgrading of a local industry or the opening of a plant to mass produce a new product made possible by research and development can be more significant to a region (at least in the short run) than the fact that the research was conducted in the region. Accordingly, to the extent that the literature permitted, our survey included the regional development implications associated with the full breadth of advancing science and technology. At the same time those aspects of this broad role most directly associated with impact in terms of jobs and income received greatest emphasis.

Report Contents

The report contains a bibliography, a commentary on the state of the art, and a discussion of action strategies. A summary of findings is presented in a separate summary report. The bibliography (Appendix A) is designed as a working tool for Commission staff members. The annotations of significant selections from the literature were written to provide the reader with a maximum of information relevant to the Commissions' needs. Special indexing procedures are incorporated to facilitate access to individual items or topics. We have also included a compilation of representative organizational forms which have been employed to capitalize on or stimulate the development of regional scientific and technological capabilities (Appendix B).

Strategies for action are discussed within the framework of location requirements since the various action forms represent, for the most part, efforts to enhance the area's locational attributes or to correct deficiencies.

II. CHARACTERISTICS OF SCIENCE AND TECHNOLOGY

A. What Do We Mean by Science and Technology?

Science and technology mean different things to different people. The Department of Labor defines technological change as:

> ". . . new arrangements in the process of production and distribution which make possible new or improved products or services. The basic characteristic of technological change is that it permits resources to be utilized more efficiently. For a given amount of output, less capital, labor, and material inputs may be required; or the same amount of resources may allow greater output to be produced."1/

The economist views technology in terms of shifts in production functions brought about by use of improved equipment and materials, better organization, etc.2/ To many, the term "science and technology" is synonomous with "research and development" -- itself a somewhat vague term. Some, for example, think only in terms of laboratories and testing stations. Others view research and development more broadly. To Dr. R. W. Olson, Vice President for Research and Engineering of Texas Instruments,

> ". . . research and development covers a good deal more than mere scientific research. In fact, scientific research in the university sense, is merely the starting point. There is no clear demarcation anywhere through research, development, engineering and preliminary pilot plant operations. From pilot plant to production is solely a matter of yield; some of our best research is necessary in mechanization. We prefer to use Total Technical Effort."3/

1/ U.S. Department of Labor, Bureau of Labor Statistics, Technological Trends in Major American Industries, Bulletin No. 1474, U.S. Government Printing Office, Washington, D.C., February 1966, p. 1 (89).

2/ Mansfield, Edwin, "Technological Change: Measurement, Determinants, and Diffusion," The Employment Impact of Technological Change, Appendix Vol. II of Technology and the American Economy, Report of the National Commission on Technology, Automation, and Economic Progress, U.S. Government Printing Office, Washington, D.C., February 1966, p. II-99 (42).

3/ Olson, R.W., "Corporate Investments in and Returns From Major R/D Projects," Paper presented at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963, p. 8-2 (49).

With regard to the role of research in economic progress, Irving Siegel has stated the following:

> "The direct product of research is, of course, information -- not investment in new processes, equipment, materials, or products. . . .that is, research clearly adds to the stock of known and often useable specific inputs, outputs, and processes; but it does not guarantee actual innovation and widening commercial use, or rising output per capita, or rising productivity.
>
> "The main role of research is to multiply technical and economic opportunities, but the quality of entrepreneurship, market conditions and other factors determine whether or not such opportunities will be realized."1/

In the same vein, Dr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology, divides technological change into three distinct steps or elements -- invention, innovation, and diffusion.2/ Invention involves the creation of an idea. Or, in the terms of the Department of Commerce Panel on Invention and Innovation, invention is the conception of an idea. Innovation is the use of an idea -- "the process by which an invention or idea is translated into the economy."3/ According to Dr. Hollomon,

> "innovation does not involve the same kind of creative ingenuity as does invention but another kind, that of the entrepreneur. The successful entrepreneur is willing to innovate, to undergo the difficulties of change, and is ingenius enough to bring it off."

The third step in the process of technological change is diffusion -- the spread of the new technology into other parts of the industry and into other industries.

1/ Siegel, Irving H., "The Role of Scientific Research in Stimulating Economic Progress," American Economic Review, Vol. L, No. 2, May 1960, pp. 343-44 (65).

2/ Hollomon, J. Herbert, Technology Transfer, Address before the Conference on Technology Transfer and Innovation, National Planning Association, Washington, D.C., May 16, 1966.

3/ U.S. Department of Commerce, Technology Innovation: Its Environment and Management, A Report by the Panel on Invention and Innovation, U.S. Government Printing Office, Washington, D.C., January 1967, p. 2 (88).

Technological change clearly encompasses much more than simply research and development. The Panel on Invention and Innovation has attempted, on the basis of the experience of its individual members, to allocate costs involved in the developing and introducing of successful product innovations. Figure 1 shows that research, advanced development and basic invention account for less than 10 percent of the cost of the total innovation effort.

By the same token, R&D employment accounts for just a fraction of the total employment in any given industry. For all industries, there are approximately six R&D scientists and engineers for every 1,000 employees. The ratio on an industry-by-industry basis, ranges from a low of one R&D scientist or engineer for every 10,000 employees in railroad transportation and in finance, insurance and real estate to a high of 897 for every 10,000 in the engineering and scientific instruments industry. Other manufacturing industries which register a relatively high percentage of R&D scientists and engineers include: ordnance (7.76%), industrial chemicals (6.12%), drugs (7.79%), office machines (5.90%), electrical distribution equipment and industrial apparatus (6.49%), communication equipment (7.74%), radio and TV sets (7.29%), and aircraft and parts (7.92%).1/

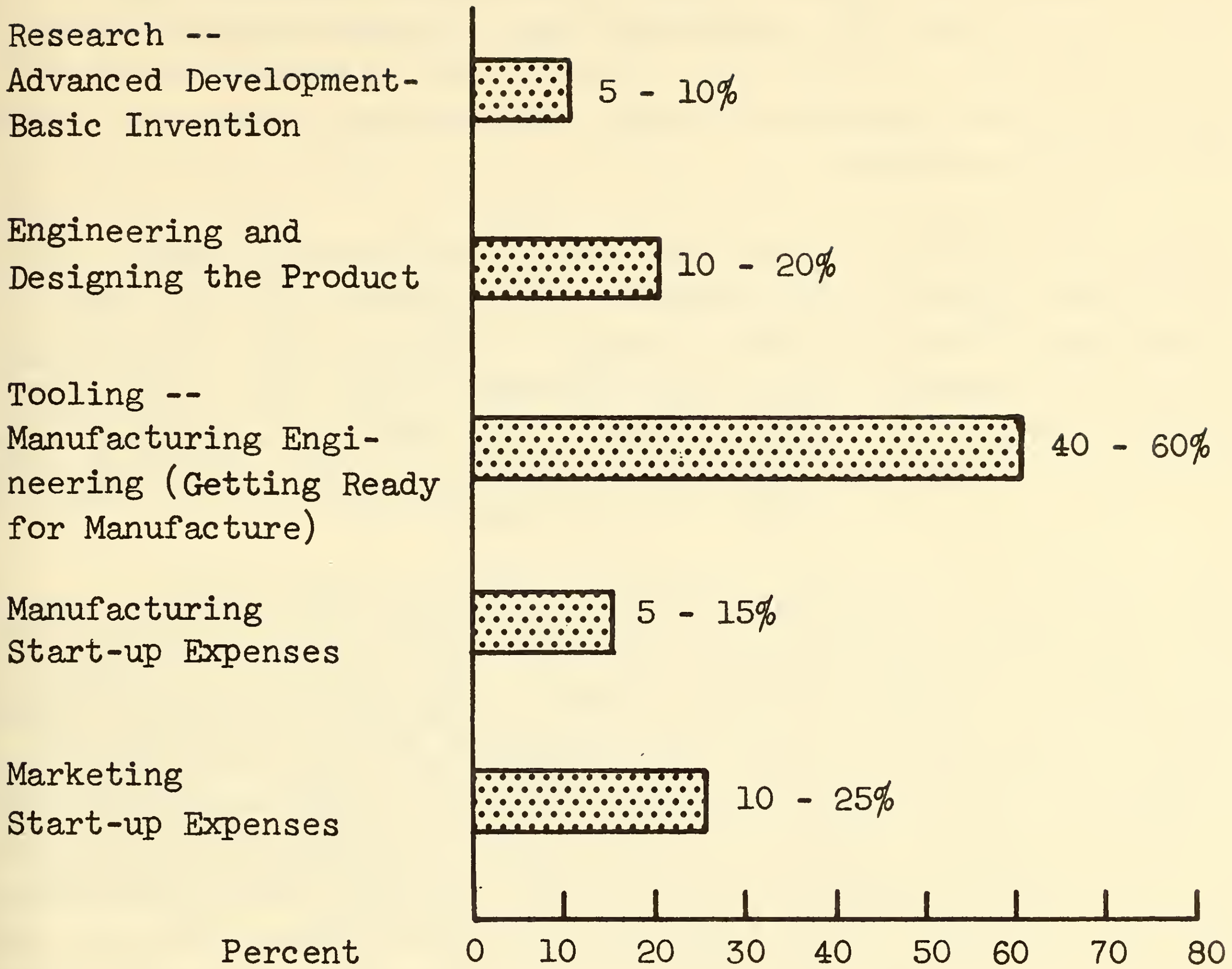
R&D serves as a catalyst and is not an end in itself. R&D yields the scientific and technological advances -- the new products and processes -- which result in production employment.

Thus, in this report the term "science and technology" is used in its broadest possible context. Under this broad umbrella we are free to deal with questions ranging from the dollar impact of R&D itself, policies regarding university education and basic research to local development programs designed to attract science-related industry as well as the impact of technological change on industries traditionally located in the area. Any narrower view would exclude important questions of relevance to regional planning and development organizations.

B. What Has Been the Impact of Technology in Our National Economic Growth?

There is no question that technology has played a significant role in shaping the course of our economic growth, and in recent years economists have attempted to measure the extent of this impact.

1/ U.S. Department of Labor, Bureau of Labor Statistics, Employment of Scientific and Technical Personnel in Industry, 1962, Bulletin No. 1418, and Employment and Earnings Statistics for the United States, 1909-1965, Bulletin No. 1312-3, December 1965.



Source: U. S. Department of Commerce, Technological Innovation: Its Invironment and Management, A Report of the Panel on Invention and Innovation, U. S. Government Printing Office, Washington, D. C., January 1967, p. 9, (88).

Figure 1 - Typical Distribution of Costs in Successful Product Innovations

Robert Solow[1] estimated that between 1909 and 1949 about 90 percent of the total increase in U.S. output per man-hour was due to technological progress. He found that the average rate of technological change increased from 1 percent per year during the first 21 years of the period to more than 2 percent during the last 19 years.

Benton Massell,[2] using a slightly different approach and a different time period (1919-55), estimated that the annual rate of technological change was about 2.9 percent. Massell also attributes approximately 90 percent of the increase of output per man-hour during the 1919-55 period to technological change.

Edward Denison[3] has found that education has made a major contribution to economic growth. He estimates that between 1929 and 1957, education raised the average quality of labor by 29.6 percent (an average annual rate of 0.93 percent). Thus, he attributes 23 percent of the annual increase in GNP to education. "The advance of all kinds of knowledge relevant to production, by permitting more to be produced with a given quantity of resources, contributed 20 percent of total growth."[4]

Some observers, although recognizing the important relationship between technology and economic growth, question the popular view that rising expenditures on research and development will ensure faster economic growth.[5] They contend that the present pattern of R&D in this country (with heavy emphasis on space and military R&D) may, in fact, tend to reduce the rate of economic growth. The reasoning is that a large proportion of the R&D resources -- funds and brainpower -- are diverted from civilian industry or growth-oriented R&D to military and space R&D.

These estimates, and those of other researchers, clearly indicate that technology has played a major role in stimulating economic growth. On the other hand, it is also clear that we are unable as yet to measure with any great precision just what impact technology has had.

1/ Solow, Robert M., "Technical Change and the Aggregate Production Function," The Review of Economics and Statistics, Vol. 39, August 1957, p. 320 (69).

2/ Massell, B.F., "Capital Formation and Technological Change in U.S. Manufacturing," The Review of Economics and Statistics, Vol. 42, May 1960, p. 18 (40).

3/ Denison, Edward F., The Sources of Economic Growth in the United States and the Alternatives Before Us, Supplementary Paper No. 13, Committee for Economic Development, New York, 1962, p. 73 (15).

4/ Ibid., p. 268.

5/ Solo, Robert A., "Gearing Military R&D to Economic Growth," Harvard Business Review, November-December 1962, p. 49 (68).

C. What is the Relationship Between Technology and the Growth of Specific Industries?

It is generally accepted that there is more than a casual relationship between the rate of growth of industries (and the individual firms within industries) and their propensity to innovate. On the other hand, the precise nature of the relationship is not known.

On the basis of his studies of individual companies and industries Edwin Mansfield[1] concludes that there is a close relationship between the amount a firm spends on research and development and the total number of important inventions it produces. Moreover, his findings show that the successful innovators in industry tend to grow more rapidly than other firms in the industry. Regarding the size of the innovator, Mr. Mansfield also found that the time a firm waits before introducing a new technique tends to be inversely related to its size and to the profitability of its investment in the innovation.

Others have arrived at similar conclusions. Yale Brozen[2] was able to show by his studies that there is a high correlation between the percentage of sales dollars spent on research and development and the average return on stockholders' investments. Studies by Booz, Allen & Hamilton[3] have shown that those firms spending the most for raw product development have experienced the greatest growth. Their comparison of research and development expenditures with industry growth rates tends to support this relationship. Studies of 10 chemical companies over a 13-year period[4] showed that for each dollar spent on research, $36 of additional sales were generated in the fourth through the tenth years after the research period.

1/ Mansfield, Edwin, "Technical Change and the Management of Research and Development," Technological Change and Economic Growth, Michigan Business Papers, No. 41, Bureau of Business Research, University of Michigan, Ann Arbor, 1965, p. 20. Also see Edwin Mansfield, "The Speed of Response of Firms to New Techniques," Quarterly Journal of Economics, LXXVII, May 1963; "Intra Firm Rates of Diffusion of an Innovation," Review of Economics and Statistics, Vol. XLV, November 1963; and "Rates of Return from Industrial Research and Development," American Economic Review, May 1965 (37).

2/ Brozen, Yale, "The Future of Industrial Research," Journal of Business, University of Chicago, October 1961, p. 434.

3/ Management of New Products, Booz, Allen & Hamilton, 1960.

4/ "Yardstick for Management," Chemical and Engineering News, Vol. 33, p. 3606, 1955.

Earlier studies by Raymond Ewell[1] have shown that there is a good correlation between the growth rate of various industries and their research and development costs. His studies also indicated that $1 of research expenditure resulted in at least $25 of added gross national product over the following 25 years. His conclusion is that rapid-growth industries tend to be high investors in research and development.

Jacob Schmookler employed a similar approach, using patent applications as the measure of inventive activity, relating this to both investment in plant and equipment and value added. He concluded that there was a strong relationship between inventive activity and industrial growth.

However, Schmookler takes issue with the popular view that invention (new products and processes) stimulates demand. He concludes that "inventors tend to allocate their activities across fields in accordance with expected demand" and that "the expected market for inventions is probably the main factor accounting for the distribution of inventive activity."[2]

Although some investigators have found that the larger firm tends to be quicker to adopt new innovations,[3] others argue that small R&D firms are more effective in developing new inventions. The Panel on Invention and Innovation concluded that "independent inventors and small firms are responsible for an important part of our inventive progress, a larger percentage than their relative small investment in R&D would suggest."[4]

In testimony before the Subcommittee on Anti-trust and Monopoly of the Senate Judiciary Committee, Jacob Schmookler stated: "On the average, very large firms seem to have to spend more than small ones to produce a patentable invention, to produce a useful invention, or to produce an important invention." Professor Hamberg of the University of Buffalo testified in a similar vein. "The brunt of the evidence is for the proposition that the large industrial laboratories are likely to be minor

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1/ Ewell, Raymond H., "Role of Research in Economic Growth," Chemical and Engineering News, Vol. 33, p. 2980, 1955.

2/ Schmookler, Jacob, Invention and Economic Growth, Cambridge, Harvard University Press, 1966, pp. 148-151 (59).

3/ Op. Cit., Mansfield (37).

4/ U. S. Department of Commerce, Technological Innovation: Its Environment and Management, U. S. Government Printing Office, Washington, D.C., January 1967, p. 17 (88).

sources of major inventions and major sources of improvements on inventions emanating from other sources."1/

This view is also held by Arnold C. Cooper2/ who concluded, on the basis of his research, that "the evidence collected suggests that large companies tend to spend substantially more to develop particular products than do small firms." His findings were based primarily on a series of interviews with men who had managed research and development in both large and small companies, as well as on comparisons of a pair of parallel development projects in which both a large and a small company had developed the same product. Cooper also found that "most of these men (those interviewed in large companies) considered their own companies to be less efficient than smaller competitors in developing new products."3/ He attributes this greater efficiency of the smaller firm to three factors:

1. Greater ability of the personnel;

2. Greater concern over costs; and

3. Fewer problems of communications and coordination.

On the other hand, the larger firm may offer certain advantages. It usually can offer greater breadth of experience as well as a greater variety of technical specialists. It tends to be better equipped to handle the large and complex research program while the smaller firm may be more effective on the smaller program.

However, virtually every author on the subject of research efficiency of large vs. small firms qualifies his findings as preliminary and tentative, and points to the need for more research on the subject.

1/ U. S. Congress, The Impact of Federal Research and Development Policies upon Scientific and Technical Manpower, Report and Recommendations of the Subcommittee on Employment, Manpower, and Poverty of the Committee on Labor and Public Welfare, 89th Congress, Second Session, U. S. Government Printing Office, Washington, D.C., 1966, p. 45 (84).

2/ Cooper, Arnold C., "R&D is More Efficient in Small Companies," Harvard Business Review, Vol. 42, No. 3, May - June 1964, p. 75 (10).

3/ Ibid., p. 77 (10).

III. RELATIONSHIP OF SCIENCE AND TECHNOLOGY TO REGIONAL GROWTH

The preceding section considered the general characteristics of science and technology and the impact on national economic growth. This section focuses on the region, and explores what is known and what is not known about the role of science and technology in regional economic development.

A. Regional Development Goals

The goals of most regional development organizations are to improve employment opportunities and to increase levels of per capita income by attracting new business and industry to the region, encouraging expansion of existing activity, and upgrading the general level of skill requirements. Because technology appears to play such a dominant role in national economic development, there has been a growing tendency on the part of regional organizations to promote science and technology as a means of stimulating economic growth.

B. Ways in Which Science and Technology Can Affect Regional Growth

Science and technology clearly have had a profound influence on the course of economic growth in different regions of the country. As often as not, the advance of technology has created problems for regions. For example, technological advance in agriculture has resulted in a decline in employment opportunities in many of our agricultural regions at a rate more rapid than could be offset by increasing nonfarm employment opportunities in those regions. The result, of course, has been significant out-migration of population from regions traditionally heavily dependent upon agriculture. Again, technological advance in energy conversion coupled with advances in mining technology have had similar adverse effects on coal mining regions.

On the other hand, the application of new technology can have significant positive impacts on regional economic growth. For example, the adoption of new technology by a local firm generally will improve that firm's competitive position in its industry, which may in turn encourage expansion and new job opportunities. The development of new processes for making soluble, edible packaging film from corn has resulted in new industry in Nebraska. New technology may also make possible the development of

under-utilized regional resources. The anticipated revitalization of the Minnesota Iron Range country as a result of developments in the processing of taconite is a case in point.

Or science and technology can lead to entirely new industries. For example, a breakthrough in data processing has resulted in a new automatic bank accounting system, and an industry employing 3,000 people has been established in Phoenix. The development of the Xeroxing process has resulted in major new employment opportunities in the Rochester, New York, area.

Research and development activity, itself a "growth industry," can have a positive impact on a region. Research and development requires employment of scientists, engineers, and technicians with relatively high wage and salary levels. Under certain conditions, the presence of research and development activity may serve as a stimulus for attracting related R&D or technology-based industries to the region. Huntsville, Alabama, for example, was a small agricultural community of 16,450 in 1950. Then the National Aeronautics and Space Administration, Marshall Space Flight Center was established at the deactivated Redstone Arsenal. With the expansion of our space program, Huntsville has grown to a city of 143,000. More than 30 contractors and space-related companies such as Boeing, IBM, and General Electric have established facilities in the area.

North Carolina's Research Triangle provides another illustration. For several years following establishment of the Research Triangle Institute and research park, development was slow. Recently, however, the pace increased, with organizations like IBM, Monsanto, and the Public Health Service Environmental Health Center locating in the area.

The concentration of scientists and engineers which accompanies this development yields further advantages to the community. In the case of Huntsville it has meant progress in education, race relations, urban renewal and cultural affairs.

Though the number of NASA Marshall Space Flight Centers, Bureau of Standards Environmental Science Services Centers, and AEC Oak Ridge Laboratories is limited, the stimulus provided by these facilities for development of further science-based activity is indicative of the impact that R&D facilities can have on other areas.

C. A Look at the Technology-Intensive Industries

We have referred to science-based industries or industries characterized by relatively high rates of technological advance. For lack of better measures we use R&D expenditures and number of scientists, engineers and technicians as indicators of the degree of scientific or technological orientation. Thus, for purposes of this report, science-based industries are those in which R&D expenditures and employment of scientists, engineers and technicians are high in relation to total output or employment.

Distribution of R&D Funds by Industry

Figure 2 shows the distribution of R&D funds by industries. Five industries, each accounting for over $1 billion in 1964, tend to dominate. The aircraft and missile industry led the list in each of the three years, followed by the electrical equipment industry. Chemicals and allied products, motor vehicles and other transportation equipment, and machinery are the other leaders in terms of R&D expenditures.

Since several of these industries are so large relative to others in absolute terms, we have also used another measure -- R&D expenditures as a percent of value added -- to identify technology-intensive industries (see Figure 3).

The general pattern is the same with two exceptions -- the petroleum refining and extracting industry and the professional and scientific instruments industry. Although R&D expenditures by these industries are small in absolute terms, they are large in relation to value added. Thus, petroleum and instruments must be classed as technology-intensive. Three of the top five industries in terms of R&D expenditures as a percent of value added were also leaders in total R&D expenditures. These industries are aircraft and missiles, motor vehicles and other transportation equipment, and electrical machinery.

Distribution of Scientists and Engineers by Industry

The numbers of scientists, engineers and technicians employed are another measure often used to identify technology-intensive industries. As shown in Figure 4, the electrical equipment and transportation equipment industries employ the largest number of scientists, engineers and technicians.

TOTAL FUNDS FOR R & D PERFORMANCE
BY MANUFACTURING INDUSTRY

1957 ▲

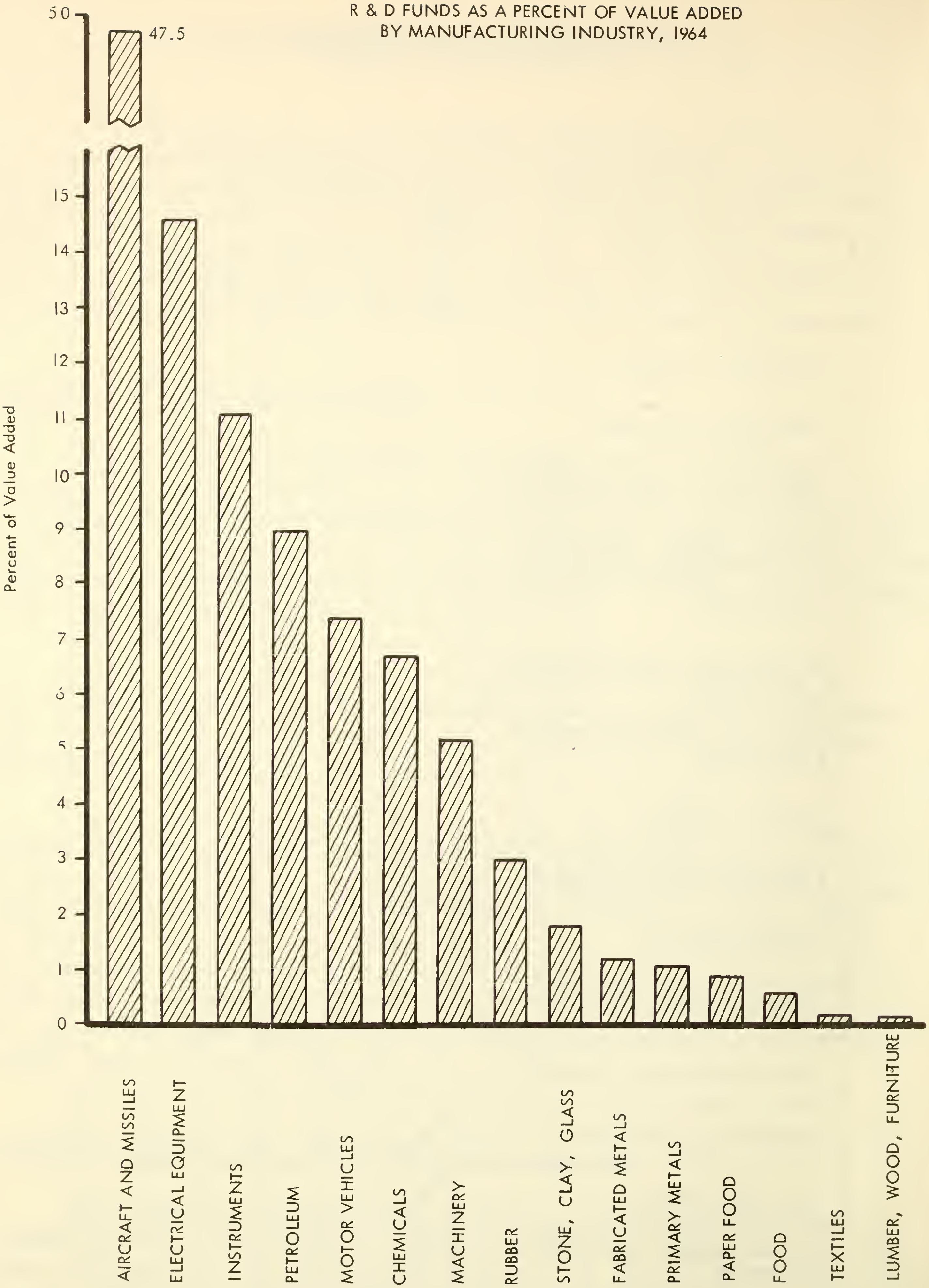
1960 □

1964 ●

	Millions of Dollars					
	Less than 100	100-499	500-999	1,000-2,499	2,500-4,999	Over 5,000
AIRCRAFT & MISSILES					▲ □	●
ELECTRICAL EQUIPMENT				▲ □	●	
CHEMICALS & ALLIED PRODUCTS			▲ □	●		
MOTOR VEHICLES AND OTHER TRANSPORTATION EQUIPMENT			▲ □	●		
MACHINERY			▲ □	●		
PROFESSIONAL AND SCIENTIFIC INSTRUMENTS		▲ □ ●				
PETROLEUM REFINING AND EXTRACTING		▲ □ ●				
PRIMARY METALS		▲ □ ●				
FABRICATED METAL PRODUCTS		▲ □ ●				
RUBBER PRODUCTS		▲ □ ●				
FOOD & KINDRED PRODUCTS	▲	□ ●				
STONE, GLASS, CLAY PRODUCTS	▲ □	●				
PAPER & ALLIED PRODUCTS	▲ □ ●					
TEXTILES & APPAREL	▲ □ ●					
LUMBER, WOOD PRODUCTS, FURNITURE	▲ □ ●					

Source: National Science Foundation, Basic Research, Applied Research and Development in Industry, 1964, June 1966, p.18.

Figure 2



Source: U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers, 1962; and National Science Foundation, Basic Research, Applied Research and Development in Industry, 1964, June 1966, p.32.

Figure 3

SCIENTISTS, ENGINEERS, AND TECHNICIANS BY INDUSTRY, 1962

Source: National Science Foundation, Scientific & Technical Manpower Resources, November 1964, p.24.

Figure 4

Chemicals and machinery follow, with technicians being relatively more important in the machinery industry. As might be expected, the industrial distribution of scientists, engineers, and technicians is similar to that of R&D expenditures.*

The number of scientists and engineers per 1,000 workers is presented in Figure 5. On this basis of comparison, petroleum refining and instruments and related products again move up to the top five, along with chemical and allied products, electrical machinery, and transportation equipment. The number of scientists and engineers per 1,000 workers ranges from a high of 170 in petroleum refining to a low of 2.7 in lumber and wood products.

D. Regional Patterns of Scientific and Technological Activity

Distribution of Industry

Technology-intensive industry is not evenly distributed throughout the country (see Tables I and II). Employment in transportation equipment, for example, is concentrated in two regions, the East North Central region and the Pacific region. The heavy concentration of employment in the East North Central region reflects the automobile manufacturing centers in that region while the aircraft and missile industry accounts for the strong showing of the Pacific region. The Middle Atlantic and East North Central regions lead in the electrical machinery industry, followed closely again by the Pacific region. Employment in the machinery industry, as might be expected, is concentrated in the manufacturing belt of the East North Central region. In the chemical and allied products industries, the Middle Atlantic region leads.

Shifting attention for the moment to the other regions, we find that the West North Central, South Atlantic, East South Central, West South Central, Mountain regions tend to concentrate employment in those industries with relatively low technology input.**

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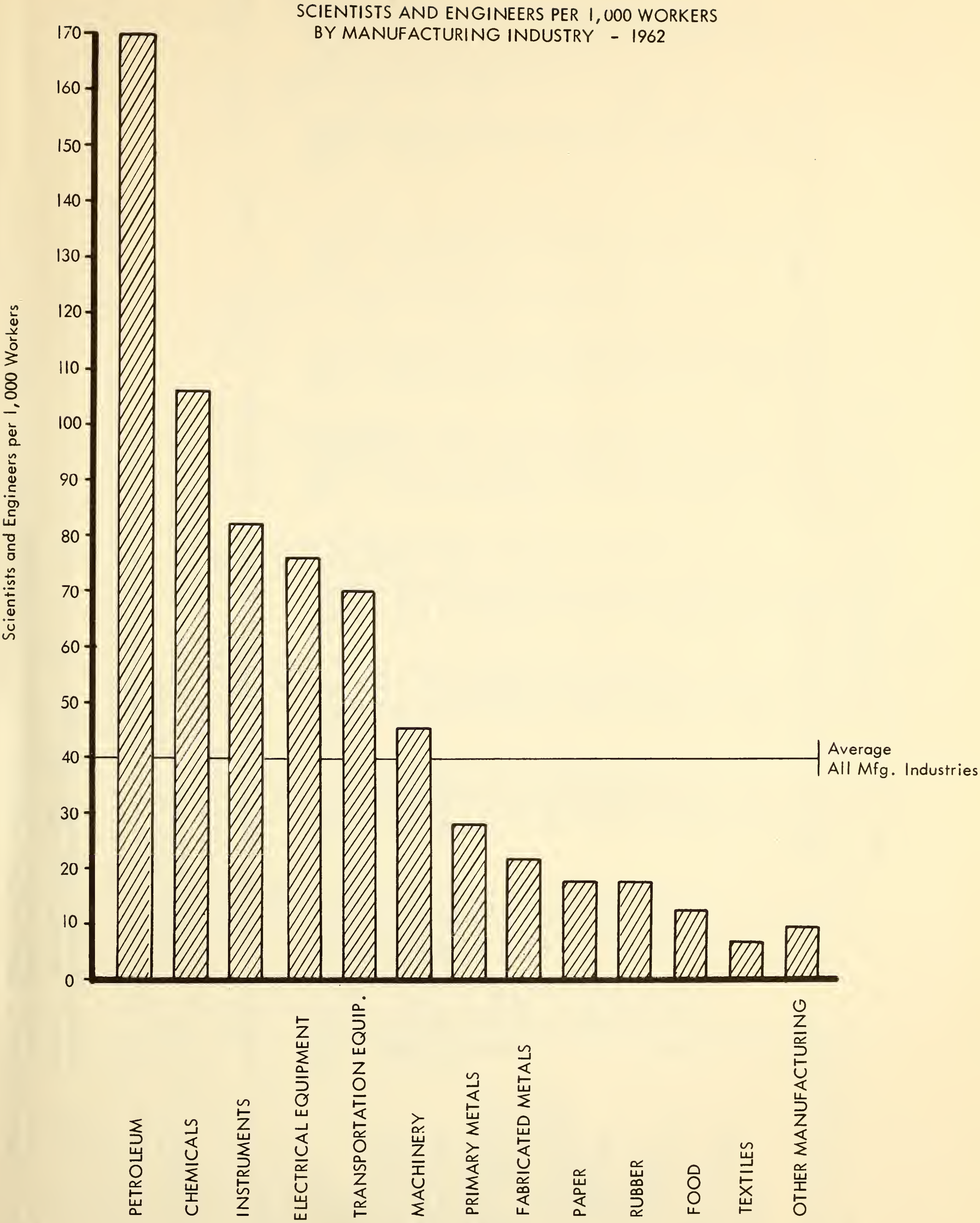
* The industrial breakdown shown in Figures 4 and 5 is different than that shown in Figure 3 because different sources of data were used.

** The fact that some of the regions, notably New England, show concentrations in certain high-technology industries as well as in low-technology industries illustrates the danger of making broad generalizations about large geographic regions.



Source: U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers, 1962, and National Science Foundation, Scientific and Technical Manpower Resources, November 1964, p.20.

Figure 5

TABLE I

EMPLOYMENT BY MANUFACTURING INDUSTRY BY REGION, 1962
(in thousands)

	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	U. S.
Food & Kindred	78.2	320.5	365.0	220.5	215.7	94.8	142.5	57.1	232.3	1,726.5
Tobacco Manufacturing	9.9	16.7	2.7	0.4	60.7	13.1	0.7	0.7	0.1	96.1
Textile Mill Products	118.9	172.8	29.5	5.7	526.8	85.2	11.1	1.0	10.4	960.6
Apparel & Related	93.2	594.3	105.3	53.7	209.7	144.4	64.8	7.0	75.7	1,348.0
Lumber & Wood Products	32.3	35.1	57.9	20.4	121.2	71.0	63.5	31.0	170.0	602.3
Furniture & Fixtures	21.3	60.1	97.7	14.1	94.2	32.2	23.4	2.9	37.0	394.0
Paper & Allied	76.6	147.8	165.2	45.4	84.2	35.4	35.5	3.1	61.4	653.3
Printing & Publishing	72.0	287.6	248.1	81.4	86.0	34.9	49.8	23.1	98.6	963.5
Chemical & Allied	36.8	247.3	180.9	46.6	172.5	71.8	73.8	9.5	60.7	899.8
Petroleum & Coal Products	2.0	45.3	36.7	9.3	5.5	3.1	66.3	6.5	33.3	208.1
Rubber & Plastic Products	72.4	81.0	169.0	17.9	26.5	18.0	10.6	7.1	29.6	431.0
Leather & Leather Products	117.0	112.7	56.3	38.9	18.5	25.2	10.5	2.6	7.1	383.9
Stone, Clay & Glass Prod.	25.1	152.9	157.5	38.0	85.2	32.2	44.3	16.4	56.9	607.5
Primary Metals Industries	62.1	348.8	463.8	27.5	85.9	69.7	36.1	27.5	69.6	1.190.2
Fab. Metal Products	103.8	257.2	435.4	61.6	68.1	52.4	53.1	10.8	110.6	1.152.7
Machinery, Exc. Elec.	161.1	338.8	639.9	107.6	60.3	34.3	60.4	15.2	105.3	1,522.7
Electric Machinery	168.5	449.7	498.7	78.3	84.7	49.7	39.2	13.4	232.2	1,614.4
Transportation Equip.	108.7	185.7	632.9	104.7	108.0	31.6	68.1	25.4	312.0	1,577.2
Instruments & Related	50.3	168.7	79.0	23.8	10.9	4.3	8.9	2.0	28.6	367.4
Miscellaneous	65.2	147.5	95.1	22.0	21.0	11.1	10.0	3.6	25.1	400.4
Ordinance & Acc.	32.9	22.1	24.0	21.2	29.8	3.6	6.4	29.0	108.3	277.4
	1,494.1	4,198.6	4,530.3	1,039.0	2,177.3	950.9	879.1	295.0	1,866.6	17,398.3

Source: National Planning Association, State Employment, by Industry: A Revised Series, 1947-62, Report No. 64, IV.

Note: New England - Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic - New Jersey, New York, Pennsylvania
East North Central - Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central - Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
South Atlantic - Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
East South Central - Alabama, Kentucky, Mississippi, Tennessee
West South Central - Arkansas, Louisiana, Oklahoma, Texas
Mountain - Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific - Alaska, California, Hawaii, Oregon, Washington

TABLE II

PERCENTAGE DISTRIBUTION OF INDUSTRIAL EMPLOYMENT BY REGION, 1962

	New England	Middle Atlantic	East North Central	West North Dentral	South Atlantic	East South Central	West South Central	Mountain	Pacific	United States
Food & Kindred	4.5	18.6	21.1	12.8	12.5	5.5	8.3	3.3	13.5	100.0
Tobacco Manufacturers	0.9	17.4	2.8	0.5	63.2	13.7	0.7	0.7	0.1	100.0
Textile Mill Products	12.4	18.0	3.1	0.6	54.8	8.9	1.2	0.1	1.2	100.0
Apparel & Related	6.9	44.1	7.8	4.0	15.6	10.7	4.8	0.5	5.6	100.0
Lumber & Wood Products	5.4	5.8	0.6	3.4	20.1	11.8	10.6	5.2	28.2	100.0
Furniture & Fixtures	5.4	17.5	24.8	3.6	23.9	8.2	5.9	0.7	9.9	100.0
Paper & Allied	11.7	22.5	25.3	6.9	12.9	5.4	5.4	0.5	9.4	100.0
Printing & Publishing	7.3	29.3	25.2	8.3	9.0	3.6	5.1	2.4	10.0	100.0
Chemical & Allied	4.1	27.5	20.1	5.2	19.2	8.0	8.2	1.1	7.8	100.0
Petroleum & Coal Products	1.0	21.8	17.6	4.4	2.7	1.5	31.9	3.2	16.0	100.0
Rubber & Plastic Products	16.8	18.8	39.1	4.1	6.1	4.2	2.5	1.7	6.9	100.0
Leather & Leather Products	29.2	29.4	14.7	10.1	4.8	6.6	2.8	0.7	1.9	100.0
Stone, Clay, & Glass Products	4.1	25.0	25.9	6.3	14.0	5.3	7.3	2.7	9.4	100.0
Primary Metals Industry	5.2	29.2	39.0	2.3	7.2	5.9	3.0	2.3	5.9	100.0
Fabricated Metal Products	9.0	22.3	37.8	5.3	5.9	4.5	4.6	0.9	9.7	100.0
Non-Electrical Machinery	10.5	22.2	42.0	7.1	4.0	2.3	4.0	1.0	6.9	100.0
Electrical Machinery	10.4	27.9	30.9	4.9	5.3	3.2	2.4	0.8	14.4	100.0
Transportation Equipment	6.9	11.8	40.1	6.6	6.9	2.0	4.3	1.6	19.8	100.0
Instruments & Related	13.7	45.9	18.8	6.5	3.0	1.2	2.4	0.8	7.8	100.0
Miscellaneous	16.2	36.8	23.7	5.5	5.2	2.8	2.5	0.9	6.3	100.0
Ordinance & Acc.	11.9	8.0	8.7	7.6	10.7	1.3	2.3	10.5	39.1	100.0
Population	5.7	18.8	19.7	8.2	14.8	6.6	9.6	4.0	12.6	100.0

Note: Underlined figures indicate those industries in which the region's share of U. S. employment exceeds its share of population -- for example, New England has 12.4 percent of Textile Mill employment but only 5.7 percent of total population.

Source: National Planning Association, State Employment, by Industry: A Revised Series, 1947-62, Report No. 64-IV.

Of course, there is no reason to expect the geographic distribution of industry -- any industry -- to be even throughout the country.[1] From the standpoint of regional development, however, the regional distribution of technology-intensive industry is important. Those areas which have a large concentration of technology-intensive industries may be expected to experience the greatest growth in the years to come.

Distribution of Scientists and Engineers

The most recent listing of the National Register of Scientific and Technical Personnel in 1962 showed that there were about 215,000 employed scientists. Data on engineering personnel are available only from information in the 1960 Census of Population. However, as of that date, there were about 861,000 engineers employed in the United States.

Table III shows the wide disparity that exists in the regional distribution of both scientists and engineers. Three regions -- the Middle Atlantic, the East North Central, and the Pacific regions -- account for over 50 percent of the nation's scientists and engineers. The New England and Mountain regions have a relatively high concentration of scientists and engineers per capita.

For selected fields, however, the geographic distribution varied considerably from the overall pattern. In a special report for the Subcommittee on Employment, Manpower, and Poverty, the National Science Foundation noted that "earth scientists, for example, were most heavily concentrated in the West South Central, Mountain, and Pacific divisions -- areas in which much of the nation's petroleum and mineral resources are located. Over half of the agricultural scientists were located in the Southern and Western States -- 17 percent in the South Atlantic division and 37 percent in the Mountain and Pacific divisions. The Middle Atlantic and East North Central divisions contained about half of those in chemistry -- explained in large measure by the heavy concentrations of the chemical industry and many institutions of higher education in these areas. Almost 21 percent of the meteorologists were reported in the South Atlantic division, which includes the Washington, D. C., area where a substantial number are employed in the U. S. Weather Bureau."[2] (See Table IV.)

1/ See Harvey S. Perloff, Edgar S. Dunn, Jr., Eric E. Lampard, and Richard F. Muth, Regions, Resources and Economic Growth, Johns Hopkins Press, Baltimore, 1960.

2/ U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies upon Scientific and Technical Manpower, 89th Congress, 2nd Session, 1966, p. 27 (84).

TABLE III

GEOGRAPHIC DISTRIBUTION OF SCIENTISTS AND ENGINEERS

Area	Scientists Employed 1962 (percent)	Engineers Employed 1960 (percent)	Population 1960
New England	7.0	7.2	5.9
Middle Atlantic	22.1	21.8	19.0
East North Central	16.6	21.9	20.2
West North Central	6.3	5.9	8.6
South Atlantic	13.8	10.8	14.5
East South Central	3.4	3.6	6.7
West South Central	8.5	7.0	9.5
Mountain	5.7	3.7	3.8
Pacific	15.3	18.1	11.8
Foreign	1.4	Not Available	

Source: U. S. Congress, Report of the Committee on Labor & Public Welfare, The Impact of Federal Research and Development Policies upon Scientific and Technical Manpower, 89th Congress, 2nd Session, p. 30.

TABLE IV

SCIENTISTS IN THE NATIONAL REGISTER, BY FIELD AND GEOGRAPHIC DIVISION, 1962

Scientific and Technical Field	Number of Scientists	Percent Distribution by Geographic Division										
		Total	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	Foreign
All Fields	214,940	100.0	7.0	22.1	16.5	6.4	13.8	3.4	8.5	5.6	15.3	1.4
Agricultural sciences	12,389	100.0	3.9	6.8	11.4	9.5	16.7	5.9	8.1	15.2	21.6	0.9
Biological sciences	25,554	100.0	7.2	20.3	18.4	8.0	17.4	3.6	5.7	4.3	13.9	1.2
Psychology	16,791	100.0	7.6	27.2	18.6	7.3	11.8	2.5	4.5	3.4	16.2	0.9
Earth sciences	18,725	100.0	2.8	6.8	8.2	5.5	8.7	3.0	31.4	14.3	14.1	5.2
Meteorology	5,379	100.0	7.1	11.4	8.9	7.6	20.5	2.5	7.4	8.9	18.0	7.7
Mathematics and statistics	18,189	100.0	8.3	23.1	15.1	6.4	15.2	2.6	5.1	4.5	18.9	0.8
Physics and astronomy	25,725	100.0	10.4	24.8	14.1	4.3	13.3	2.8	4.1	5.3	20.0	0.9
Chemistry	54,130	100.0	7.4	29.2	21.2	5.8	13.2	3.6	6.3	2.6	10.3	0.4
Sanitary engineering	4,923	100.0	6.2	19.0	20.3	8.5	14.6	3.5	6.8	4.0	15.4	1.7
Other fields	33,135	100.0	5.9	23.4	16.4	5.8	13.2	3.7	9.0	4.9	16.6	1.1
Population		100.0	5.7	18.8	19.7	8.2	14.8	6.6	9.6	4.0	12.6	

Note: Percent detail may not add to totals because of rounding.
Underlined figures indicate those fields in which the regions share of scientists exceeds its share of population - for example, New England has 7.0% of all scientists but only 5.7% of U.S. population.

Source: National Science Foundation, *National Register of Scientific and Technical Personnel*, 1962.

Regarding the geographic distribution of engineers, the NSF noted: "More than two-fifths of the aeronautical engineers were located in the Pacific region, reflecting the heavy concentration of the aircraft and missiles industry in California. On the other hand, almost three-fifths of the mining engineers were employed in the West South Central and Mountain regions, where the bulk of petroleum and mineral deposits is located. About half of the mechanical and industrial engineers, and over three-fifths of the metallurgical engineers were employed in the East North Central and Middle Atlantic regions, where much of the nation's heavy manufacturing industry is located."1/ (See Table V.)

The distribution of individual specialties or groups of specialties is substantially more significant than aggregate statistics on distribution of scientists and engineers, and is a more meaningful guide for regional action programs.

There is no question that the regional distribution of scientists and engineers is uneven. But the same is true of other occupations, too. There are more movie cameramen in Los Angeles than in Minneapolis, for example. People in this country are highly mobile -- scientists and engineers are among the most mobile of the workforce. They, along with others, will gravitate to locations offering employment for their particular specialty.

The "Brain Drain" -- a Valid Complaint?

It has often been implied -- and to some extent confirmed by studies and congressional hearings -- that certain regions of the country are suffering from a "brain drain." Table VI indicates just how great these gains and losses from one region to another have been.

The level of technological activity in a region is not necessarily related to the production of scientists and engineers in that region. For example, "over the years the State of Illinois has been one of the outstanding producers of Ph.D. scientists: nearly one-tenth of all the Ph.D. scientists in the nation received their doctorate training in Illinois -- more than have been trained in Massachusetts, Pennsylvania, or California. In fact, more than any state except New York.

1/ U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies upon Scientific and Technical Manpower, 89th Congress, 2nd Session, 1966, p. 27 (84).

TABLE V

EMPLOYED MALE ENGINEERS, BY FIELD OF ENGINEERING AND GEOGRAPHIC DIVISION, 1960 CENSUS

Field	Number of Engineers	Percent Distribution by Geographic Division									
		Total	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
All Fields	853,738	100.0	7.2	21.8	21.9	5.9	10.8	3.6	7.0	3.7	18.1
Aeronautical	50,895	100.0	7.0	11.5	10.9	7.9	8.5	1.5	7.5	2.7	42.4
Chemical	40,637	100.0	4.9	26.0	19.6	4.7	13.2	4.9	13.3	2.6	10.8
Civil	154,293	100.0	6.2	18.3	16.7	7.6	12.5	5.8	8.6	5.3	19.0
Electrical	182,413	100.0	7.2	26.3	17.0	5.2	12.1	3.1	5.5	3.9	19.7
Industrial	95,389	100.0	8.5	22.7	27.2	6.1	11.0	3.9	4.9	2.5	13.2
Mechanical	157,660	100.0	7.7	20.9	30.0	5.2	8.7	3.0	5.2	2.8	16.5
Metallurgical and metallurgist	18,280	100.0	7.2	29.7	33.1	3.0	5.4	4.0	2.3	4.5	10.8
Mining	12,042	100.0	0.8	7.8	6.0	6.4	7.2	3.2	44.1	14.1	10.4
Sales	56,664	100.0	7.9	24.5	28.9	5.6	8.4	2.6	7.3	2.2	12.6
Other fields	85,465	100.0	7.8	21.9	23.5	5.6	11.9	3.0	5.6	3.9	16.8
Population		100.0	5.7	18.8	19.7	8.2	14.8	6.6	9.6	4.0	12.6

Notes: Percent detail may not add to totals because of rounding. Underlined figures indicate those fields in which the region's share of engineers exceeds its share of population.

Source: U. S. Department of Commerce, Bureau of the Census, United States Census of Population, 1960, series PC(1)-D, Detailed Characteristics, for each State.

TABLE VI

MOBILITY OF DOCTORAL SCIENTISTS BETWEEN GEOGRAPHIC DIVISIONS

Geographic Division	Doctoral Award	Losses From	Gains Into	Net Mobility
TOTAL	34,870	2,706	2,706	--
New England	3,721	2,710	1,715	-985
Middle Atlantic	7,405	3,709	4,567	858
East North Central	9,956	6,564	2,978	-3,586
West North Central	3,639	2,759	1,389	-1,370
South Atlantic	2,702	1,498	3,950	2,452
East South Central	427	277	956	679
West South Central	1,161	638	1,406	768
Mountain	569	363	1,396	1,033
Pacific	3,923	1,838	2,787	949
Foreign	1,131	1,314	268	-1,046
No Report	36	36	294	258

Source: U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies Upon Scientific and Technical Manpower, 89th Congress, 2nd Session, p. 3.

Illinois is not experiencing the kind of technological boom that is going on in other regions -- in part because only one Illinois-educated Ph.D. in five is working in Illinois."1/ "Arizona has drawn five times as many Ph.D.'s as it has educated. And New Mexico, with the Los Alamos Laboratory and sunshine, has drawn more than ten times its output."2/

A Senate Subcommittee investigating the impact of federal research and development policies on the scientific and technical manpower of the U. S. found that "research and developments funds act as an important magnet drawing highly trained scientific and technical manpower to the area or establishment in which the funds have been placed."3/ In the same report the President of the University of Wisconsin brought out the point that "As of 1963 California had produced 6,136 Ph.D.'s in the sciences and engineering, but had 8,005 employed in the State. Wisconsin, in the same period, had produced 3,286 Ph.D.'s but employed only 1,226."4/

The mobility of scientists and engineers was further illustrated by Dr. Jerome B. Wiesner, then the President's Science Adviser, spoke "of the university in the Midwest that trained on the order of 150 Ph.D.'s in solid-state physics since the war. Only one of those people is left in the Midwest."5/ The figures in Table VII suggest that this gap is widening.

Characteristics of the "Lagging" Regions

We have shown that certain regions lag behind others in terms of scientific activity. These "lagging" regions usually exhibit one or more of the following characteristics.

In the first place, the regions which have lower levels of scientific and technological activity (as measured by employment of scientists

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1/ Allison, David, "The University and Regional Prosperity," International Science and Technology, April 1965, p. 23 (1).
2/ Ibid., p. 31 (1).
3/ U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies Upon Scientific and Technical Manpower, 89th Congress, 2nd Session, p. 3 (84).
4/ Ibid., p. 36 (84).
5/ U. S. Congress, Senate Hearings Before a Subcommittee of the Select Committee on Small Business, The Role and Effect of Technology in the Nation's Economy, 88th Congress, 1st Session, Part 3, p. 208 (83).

TABLE VII

LOCATION OF DOCTORAL SCIENTISTS AT SELECTED CAREER POINTS BY GEOGRAPHIC DIVISIONS

Geographic Division	Doctoral Award	Employment 1960	Employment 1963	Employment 1964	Net Mobility 1964
New England	3,721	2,726	2,733	2,694	-1,027
Middle Atlantic	7,405	8,263	8,271	8,120	+ 715
East North Central	9,956	6,370	6,222	6,149	-3,807
West North Central	3,639	2,269	2,266	2,246	-1,393
South Atlantic	2,702	5,154	5,315	5,426	+2,724
East South Central	427	1,106	1,090	1,087	+ 660
West South Central	1,161	1,929	1,926	1,881	+ 720
Mountain	569	1,602	1,652	1,648	+1,079
Pacific	3,923	4,872	5,111	5,238	+1,315
Foreign	1,331	285	284	381	- 950
No Report	36	294	--	--	--

Source: U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies Upon Scientific and Technical Manpower, 89th Congress, 2nd Session, p. 3.

and engineers, concentrations of technology-intensive industry, and level of R&D expenditures) tend to be experiencing less rapid rates of population growth (see Table VIII).

TABLE VIII

POPULATION GROWTH, PER CAPITA INCOME, AND MEDIAN SCHOOL YEARS COMPLETED

Region	Population Growth 1940-1965 (%)	Per Capita Income 1965	Median School Years Completed[a/] 1960
New England	31.9	$2,979	11.2
Middle Atlantic	32.1	3,079	10.5
East North Central	43.2	2,964	10.7
West North Central	17.5	2,587	10.7
South Atlantic	61.1	2,354	9.8
East South Central	18.8	1,905	8.8
West South Central	41.8	2,217	9.9
Mountain	87.4	2,477	12.0
Pacific	139.1	3,116	12.0

a/ By persons 25 years and older.

Sources: U. S. Department of Commerce, Bureau of the Census, U. S. Census of Population, 1950 and 1960; Department of Commerce, Statistical Abstract of the U. S., 1966; Department of Commerce, Bureau of the Census, Statistical Abstract, 1966.

Moreover, these same regions have lower levels of per capita income (see Table VIII). The Pacific, Middle Atlantic, New England and East North Central regions all have per capita income levels above the U. S. average, and tend to have high levels of scientific and technological activity. In the remaining five regions -- with relatively less scientific orientation -- per capita incomes fall below the national average.

Patterns in the level of educational attainment yield similar results (see Table VIII). Although there are minor deviations in the ranking, education levels tend to be lower in those regions with lowest levels of scientific activity.

The level of unemployment is another indicator often used to measure regional economic well-being. When considering this the pattern is somewhat different. Those areas with a large percentage of R&D industries often have higher unemployment rates than those regions with the smaller amount of R&D.

However, it does not necessarily follow that these two facts are directly related. As an example, the Pacific region -- with a large amount of R&D and a growing economy -- is also an area with a rapidly growing population and also has a relatively high unemployment rate. One explanation of this is that labor has migrated to areas which appear to offer greater opportunities at a rate faster than they can be assimilated. Other areas -- with slower growth and a more stable economy -- do not have nearly as high an unemployment rate. This may be because the unemployment data does not adequately reflect the true picture -- particularly the under-employment of human resources.

E. What Can We Conclude About the Role of Science and Technology in Regional Development?

The evidence suggests that:

1. There is a direct relationship between the growth of a firm or industry and the level of investment in research and development.

2. Scientific activity (measured in terms of research and development investment and/or number of scientists and engineers) is not evenly distributed throughout the various regions of the country.

3. The rapid-growth regions, which include the concentrations of technology-intensive industries, also are the regions with the high research and development expenditures and concentrations of scientists, engineers and technicians. The logical conclusion is that the relationship is more than just coincidence.[1/]

Because of the close relationship between R&D and regional growth, it is often asserted that research and development activity in a region or community will stimulate additional R&D activity and related manufacturing employment. This assumed cause and effect relationship is

1/ Horowitz, Ira, "Some Aspects of the Effects of the Regional Distribution of Scientific Talent on Regional Economic Activity," Management Science, Vol. 13, No. 3, November 1966, p. 217 (26).

supported by many who point to development in the San Francisco Bay area and along Boston's Route 128 as outstanding examples. The assumption is that research conducted by laboratories in the area will create new economic opportunities in the form of new products, processes, and services. It is then assumed that as these products and processes become commercially feasible, production will occur at or near the location where they were developed. This statement of the development process is, of course, oversimplified yet widely accepted.

The pull of R&D as a determinant of production location seems to be strongest in the case of defense development contracts. Few are surprised when production contracts are awarded to the firm which conducted the initial development and design studies. Yet, even in such seemingly straightforward cases as this, other considerations can override these locational tendencies.

It is important to consider other explanations or variations of the development process. For example, in many instances growth occurring near existing R&D laboratories is not necessarily attributable directly to the <u>results</u> of local research. On the contrary, much of the growth during the early period of development will come from firms in other areas of the country who choose to locate branch plants or R&D facilities near the existing R&D center, because of support services provided by the center, prestige, or other reasons. Thus, R&D activity is viewed as a locational asset which serves to attract additional science-based activity.

Also, new products and processes are not necessarily destined to have employment and income impact in the region where the R&D occurs. For example, the C5-A aircraft which the Lockheed Corporation has contracted to build will have employment and income impact mainly in the Atlanta, Georgia, metropolitan area even though much of the R&D underlying this project was conducted in California. As another case in point, much of the research on semiconductors was conducted in Indiana and New Jersey (Purdue University and the Bell Telephone Laboratories), but aggressive management at Texas Instruments became heavily involved in utilizing this research. The result has been a rapid growth of the company in Dallas, with many subsequent impacts on the firm and the community. The research laboratories of Monsanto are located in the St. Louis metropolitan area; yet the employment impact of this research is felt at Monsanto production facilities located throughout the country. Many similar examples could be cited. The point is that a region can capitalize on the employment and income benefits of R&D even though the R&D itself is carried on outside the region.

On the other hand, R&D efforts have often led to economic benefits for the region in which the work was conducted. Technical developments in the processing of taconite have resulted in a revitalization of the northern Minnesota Iron Range country. Much of the R&D associated with these developments was conducted in the region. Another example is the growth of the aircraft industry in California. Here also, much of the R&D work is done in the same area. The Bureau of Standards research laboratory in Boulder, Colorado, and the University of Colorado have been cited as an important reason for location there of several other firms in the area.

Ira Horowitz[1/] cites several important effects industrial R&D can have on the regional economy. He suggests that the firm exploiting the results of R&D may be inclined to establish production facilities near its R&D facilities for either of two reasons: (1) A firm's R&D and production facilities, if not located in the same plant, are often close together, and since a technological advance is often a refinement or extension of existing operations, the new activity will be located close to the old; or (2) there may be fewer complications if the people who develop the new products or processes are close by to deal with any problems that might arise.

Companies are interested in locating near the source of supply of scientists and other technical personnel. Although scientists tend to be highly mobile, it is generally less of a problem to staff a research laboratory in an area where there are large numbers of these people to draw from. Moreover, experience has shown that scientists prefer to locate in areas which offer a variety of employment opportunities close at hand -- where a move from one research firm to another results in a minimum of inconvenience not only to the scientists but to the company as well. Thus, the region or community which has been successful in developing science-based activity finds itself in a strong competitive position for further development.

1/ Horowitz, Ira, "Some Aspects of the Effects of the Regional Distribution of Scientific Talent on Regional Economic Activity," Management Science, Vol. 13, No. 3, November 1966, p. 217 (26).

F. Gaps in Our Knowledge

Although economists have developed procedures for measuring technological change for the nation, some of the basic data inputs are lacking at the regional level.1/ Although we are quick to recognize that the real payoff from research and development comes only after the diffusion of new ideas, concepts, products, and processes has occurred throughout different industries, we still know very little about the actual process of technology transfer. We have only begun to scratch the surface of major questions relating to size and economies of scale in research and development. We can identify numerous factors which appear to be influential in R&D lab location decisions, but many questions relating to location decisions remain unanswered.

1/ For a more detailed discussion of regional data limitations see Weidenbaum, Murray L., "Measurements of the Economic Impact of Defense and Space Programs," American Journal of Economics and Sociology, p. 413 (93); and U. S. Congress Joint Economic Committee, Improved Statistics for Economic Growth, 89th Congress, 1st Session, July 1965.

IV. ALTERNATIVE ACTION FORMS AND THEIR DETERMINANTS

The view is widely held that overt efforts to upgrade the level of technology in a region will help to stimulate regional economic development. A number of different types of institutions and programs have accordingly been established.

Approaches vary widely. What is appropriate for the San Francisco Bay area is not necessarily the most suitable form of action for the Ozarks region. The purpose of this section, therefore, is to examine some of these alternative institutions and action forms in order to illustrate the range of alternatives available and the characteristics and conditions necessary for each.

A. The Role of Education

Many observers contend that a strong university, particularly in the sciences and engineering, is essential if the area is to attract other types of scientific activities. Above-average elementary and secondary education facilities are important in attracting the needed scientists and engineers. Availability of a technically trained labor force is a major factor influencing the location of technology-intensive industry, and is a key to upgrading the level of industrial activity in the region. Education is also important in another sense -- that of creating a public awareness of problems of the region and the need for upgrading the level of technical competence of the region's population and industry. Each of these aspects of education is examined in more detail in the following sections.

The Importance of the University

It is often said that a strong university, particularly in the science and engineering fields, is a prerequisite for the development of a scientific industry and R&D complex. All one has to do is to point to the developments in California and Massachusetts. Around such institutions as MIT, Harvard, Stanford, and Cal Tech, new industries have grown and multiplied. There seems to be little doubt that a strong university is a major asset -- some would say a necessary condition -- for development of scientific activity.

The evidence is equally convincing, however, that a strong university alone is not a sufficient condition for development of scientific activity. For example, some of the most highly rated engineering and science universities in the United States are in the Middle West, yet this area has not seen the rapid growth of new research-based industry. The purpose of this section of the report is to examine some of the roles a university can play and to discuss some of the measures that have been taken at the regional level to enhance this important area resource.

The university's contribution: The university contributes to the scientific development of a region in a number of ways: as a source of technical talent for local science-based industry; by offering employees of local firms opportunities for continuing education and professional advancement; and by providing a source of technical consultants and specialized facilities and services, such as libraries and computer centers. The university may be a source of "spin-off" companies as university staff members leave the academic world to merchandise ideas or products developed in their university activities. And, above all, the university helps to provide the intellectual and cultural atmosphere which facilitates the recruiting task of area firms.

A source of talent: The university provides a region with a supply of scientists, engineers, and other technical talent. Local companies often employ students on a part-time basis and then encourage them to join the firm on a full-time basis after graduation. Close acquaintanceship with the university program and faculty allows the company to concentrate recruitment efforts on the better students, many of whom are happy to remain in the area. There is a general tendency to take jobs close at hand, all else being equal. Also, student wives, who are generally of above-average intelligence, can be hired for relatively low wages because of local labor market conditions existing in most university communities. The manager of an electronics plant in Ames, Iowa, for example, cites the availability of student wives as a primary factor in the success of his company's operations in that community.

Continuing education: Many scientists and engineers seek employment at locations where they are able to pursue advanced degrees or at least take advanced course work, and most companies encourage this. In addition, the university may provide the opportunity for part-time teaching. Lack of these opportunities close at hand presents a major obstacle to recruitment of scientific and technical personnel.

Facilities and services: A third advantage of location near a university is the availability of university facilities and services. A company located near the University of Colorado, for example, makes

extensive use of university library facilities and cites this as one of the principal attributes of its location.1/ Computer centers, specialized equipment and laboratories, and testing facilities are among the other types of services provided to industry by many universities.

University consultants: Although many firms make wide use of consultants, they often find that university faculty members lack the experience and outlook necessary for operating in a business environment. Nevertheless, this pool of technical talent serves as an attraction to many industrial firms. Universities which encourage faculty consulting have often had greater impact on science-based growth than have universities which strictly limit outside activities of faculty members.

A source of "spin-off": The university often acts as a source of "spin-off" commercial ventures which may contribute to the economic development of the region. Many of the small firms (and in some cases large ones) located in the Boston area, for example, were founded by former university personnel who left the university to establish their own companies. A Massachusetts Institute of Technology study shows that nearly 150 such companies have been formed by MIT staff members and faculty since 1945. At least 16 firms doing business in the Ann Arbor area have been spin-offs from the University of Michigan, and of those 13 have been founded since 1950.2/ However, since many strong scientific and engineering universities have spawned virtually no spin-off industries, the university alone, with all its technical talent, is not the only ingredient required.

The intellectual and cultural environment: Probably the most significant role the university plays in stimulating growth of science-based activity is to provide the intellectual and cultural atmosphere so influential in attracting scientific and technical personnel. An atmophere which is conducive to the exchange of ideas -- where a person with creative talent is welcome -- encourages the growth and development of scientific activity. This atmosphere carries over into the life of the community, usually creating high-quality elementary and secondary schools and better-than-average community facilities and services.

A number of groups have established action programs to capitalize on and enhance their higher-education resources.

1/ Bearwald, Mark, "Boulder Space Age Boom, Empire Magazine, November 13, 1966 (2).

2/ Mapes, Glenn, "Profs and Profits," Wall Street Journal, March 13, 1967, p. 1.

One approach has been to establish a research park near the university -- often under the sponsorship of the university. Although one of the first university research parks was sponsored by Stanford University in 1951, much of the growth of this type of activity has occurred since 1962. There are now around 30 research parks located near major academic centers, some of them highly successful. The 700 acre Stanford Industrial Park, for example, has 50 tenants employing a total of 12,000 people, including 6,000 scientists and engineers. Technology Square at Cambridge, Massachusetts, established on 14 acres in 1960, is 100 percent occupied with 21 tenants employing 1,000 personnel. Purdue University's industrial research park (McClure Park), developed on 100 acres in 1961, has 12 tenants with a total employment of 1,000, including 500 scientists and engineers. However, most of the research parks have not met with such glowing success. A number of those which have been established for five years or more still have only one tenant, and often that tenant is a facility of the university itself.

Proximity to a strong university undoubtedly played an important role in the outstanding success of the cited research parks. But, it is unwise to attribute success to this reason alone. For example, the Stanford Industrial Park was opened on the San Francisco Peninsula where land for industrial development is scarce.

Although it is clear that regional development via university research parks can be successful in some cases, it is equally clear that is has not been significant in others. With time, more research parks may be successful; this type of development does not occur overnight. Thus, it may be too early to properly evaluate the ultimate role of the university research park as a stimulant to area economic development.1/

Many universities are expanding and reorienting their technical assistance programs to better serve area industry. The State Technical Services program of the Department of Commerce was designed to help promote this kind of activity.2/ For example, at the Universities of Utah and Arkansas use is being made of the libraries and computer equipment for the collection and dissemination of technical information. In some cases, universities have established technical assistance centers such as

1/ For more discussion on this topic see J. P. Schwitter, "Universities as Research Park Developers," Industrial Research, April 1965 (61). For a list of research parks see "Research and Science-Oriented Park Director," Industrial Research, May 1966.

2/ For a list of STS activities see U. S. Department of Commerce, Office of State Technical Services, First Annual Report, 1966 (86).

the Center for Industrial Research and Service (CIRAS) at Iowa State University to provide advice and assistance to area industry. (These technical assistance programs are discussed in more detail in a later section of this report.)

Cooperative efforts: In many regions, the resources of area universities are being combined in an effort to better utilize facilities and personnel and to tackle mutual problems. Examples of this type of action form, discussed below, include the Committee on Institutional Cooperation, the Western Interstate Commission for Higher Education, and the Southern Regional Education Board.

Committee on Institutional Cooperation: The Committee on Institutional Cooperation was formed in 1958 by the presidents of 11 midwestern universities -- the University of Chicago, the University of Illinois, Indiana University, the State University of Iowa, the University of Michigan, Michigan State University, the University of Minnesota, Northwestern University, Ohio State University, Purdue University, and the University of Wisconsin. Its primary objective is "to improve the educational and public services offered by its member institutions -- while minimizing the cost of these services -- by fostering cooperation in instruction and research, particularly at the graduate level."1/

The CIC has recently established a staff arm, the Council on Economic Growth, Technology, and Public Policy. Its mission is to encourage member universities to work jointly on social-economic-technical problems which have a regional perspective. The Council will focus attention on such problem areas a water resources, transportation, agriculture, environmental design (including architecture, city planning, industrial design, etc.). Interinstitutional study programs in the physical sciences, with emphasis on the application of advanced technology to the problems of area manufacturers, are being encouraged. Interinstitutional cooperation in research and training programs is the approach, with the goal being regional advancement.

Southern Regional Education Board: The Southern Regional Education Board (SREB) was formed in 1948 by Interstate Compact. In addition to financial support from its member states, the Board has received supplementary funds from private foundations.

1/ Bond, Floyd A. (Editor), Technological Change and Economic Growth, Michigan Business Papers, No. 41, Bureau of Business Research, University of Michigan, Ann Arbor, Michigan, 1964.

The organization's charter specified that attention be focused on improving post-high school education. Graduate and professional education have received the greatest emphasis, although the Board has also studied and made recommendations regarding the development of community colleges (academic and vocational/technical training). The organization functions as a study, consultive, and administrative group working directly with the states on programs of higher education.

Several years ago the Governors' Conference asked the SREB to study nuclear activities in the southern states and to recommend a program designed to accelerate development on the basis of activity in this field. The SREB study resulted ultimately in the formation of the Southern Interstate Nuclear Board. Similar activities relating to mental health services in the southern states are under way.

Western Interstate Commission for Higher Education: The organization is involved in cooperative efforts designed to strengthen higher education generally throughout the West. Emphasis is on the health sciences and related social sciences, with activities including manpower development programs, seminars, curriculum development projects, etc.

One of its chief contributions has been in terms of promoting university involvement in science-based activities and in encouraging cooperation in these fields. It also was instrumental in stimulating the idea and providing technical assistance for the establishment of the Associated Rocky Mountain Universities (ARMU), a kind of research consortium to create and manage major research projects carried out cooperatively by member institutions, thereby capitalizing on their complementary strengths in various disciplines.

The Role of Technical Training

In discussions of technology and economic development, the role of the scientist and engineer is often emphasized at the expense of the role of the technician and other supporting manpower. A technician is defined as a "worker who directly supports scientists and engineers in designing, developing, producing and maintaining the Nation's machines and materials."1/ Two basic sets of reasons argue for more comprehensive consideration of the supply of technicians and production labor as forces in regional development.

1/ U. S. Department of Labor, Technician Manpower: Requirements, Resources, and Training Needs, June 1966, p. 1 (90).

First, research expenditures per se are only a small part of the total expenditures occasioned in the advance of science and technology. R&D spending is analogous to the visible portion of an iceberg. This can be illustrated by an examination of the distribution of the DOD budget: For each dollar DOD spends on research, it also spends $14.75 on development and $55.00 for procurement (see Table IX).

TABLE IX

DOD EXPENDITURES BY CATEGORY-FY 1963

Category		Per Dollar Spent on Research
Research		$ 1.00
R&D Management and Support		4.25
Development		14.75
Exploratory Development	$3.75	
Advanced Development	$3.50	
Engineering Development	$7.50	
Procurement		55.00

Source: Testimony of Roswell L. Gilpatric, Deputy Secretary of Defense, before Senate Subcommittee on Employment and Manpower (Committee on Labor and Public Welfare), November 6, 1963; Statistical Abstract of the United States - 1964, Bureau of the Census.

To some extent this pattern is a reflection of the multiplier effect of research. In addition, it tends to support the view that the greatest potential for regional development via science and technology is not in conducting research but rather in producing the new goods which are the fruits of research. Finally, as one moves down the chain from research to production there is a decline in the number of scientists required and an increase in the number of technicians required.

Although different industries have research-to-production ratios which differ from the DOD research-to-procurement ratio, the "iceberg" generalization holds true, as does the relative demand for scientists vs. technicians in research and production.

Second, recent studies have indicated that technicians are less mobile than scientists and engineers. Therefore, a base of technicians must be available within an area for it to experience science-based growth. Donald Murry, in his recent study, puts the technician requirement situation this way:

> "Therefore, the number of technicians available for the expansion of R&D within a region, as in the case of scientists and engineers, depends upon the locally supplied technicians or the ease with which technicians can be acquired from without the region. But, there is not the same indication that the market for technicians is national in scope as there is for scientists and engineers. If the net increase of technicians required for regional scientific research expansion is not obtainable, there is not the same indication that they can be attracted to the region from without as there is for the scientists and engineers. If the mobility of persons with these skills is considerably less, and these observations indicate that it may be, an indigenous supply of technicians is an inescapable prerequisite of scientific research."1/

During a proprietary study conducted three years ago, MRI reached similar conclusions. A majority of Ph.D.'s educated in Iowa tended to migrate from the state, while a majority of engineering technicians trained in a two-year technical training program found employment in Iowa. Others have found that the availability of technical manpower is one of the most important factors influencing the location of science-based industry.2/

The need for continued and expanded programs is further illustrated by the fact that the Labor Department estimates that the need for technicians will increase by approximately 3/4 by 1975 or nearly 1,500,000 technicians.3/

In the nation as a whole, almost four times as many students were enrolled in agricultural-training programs as were enrolled in technical education (see Table X).

1/ Murry, Donald A., Scientific Research in Missouri, University of Missouri, February 1965 (41).

2/ Danilov, Victor J., "What Makes a Desirable Science Site," Industrial Research, May 1966, p. 38.

3/ U. S. Department of Labor, Op. Cit., p. 3 (90).

TABLE X

FEDERALLY AIDED VOCATIONAL PROGRAMS -- 1964

	Students	Total Expenditures ($ Millions)
Agriculture	860,600	77.5
Trades and Industry	1,069,300	103.2
Home Economics	2,022,100	89.9
Distributive Occupations	334,100	14.9
Practical Nursing	59,000	12.4
Technical Education[a]	221,300	34.9
Total	4,566,400	332.8

Source: Department of Health, Education and Welfare, Office of Education, Vocational and Technical Education, Fiscal Year 1964.

a/ Training of highly skilled technicians in recognized occupations requiring scientific knowledge essential in fields relating to national defense.

Since employment opportunities are declining in agriculture and expanding in technical fields, there seems to be a significant mismatch. The situation in specific regions is even less in balance. For example, in 1964 the three states partially included in the Ozarks region (Arkansas, Missouri, and Oklahoma) allocated 35.5 percent of their combined Vocational Education expenditures to agricultural training, while only 8.4 percent went to Technical Education. Enrollment was 30.3 percent in agricultural training, and 2.9 percent in Technical Education.

Advancing technology has the effect of lifting the skill requirements both nationally and regionally. The region which fails to upgrade the skill level of its labor force to match these changing requirements is likely to experience lagging economic development. Thus, vocational/technical training programs play an important role in regional development.

This is true despite the fact that the skill level of the work force has been increasing significantly in recent years. Since 1950, for example, employment in the white collar and service occupations has risen sharply; in blue collar occupations it has risen moderately, and the farm work force has declined. The prime movers in the white collar expansion

throughout the post-World War II period have been the professional and clerical occupations. Among blue collar workers, craftsmen have grown faster than the less skilled workers (see Table XI).

TABLE XI

MAJOR OCCUPATIONAL GROUPS OF WORKERS, ACTUAL 1964 EMPLOYMENT AND PROJECTED 1975 REQUIREMENTS

(Number in Thousands)

Occupational Group	1964 Employment Number	1964 Employment Percent	Projected 1975 Requirements Number	Projected 1975 Requirements Percent	Percent Change, 1964-75
Total, all occupational groups	70,357	100.0	88,700	100.0	26
White-collar workers	31,125	44.2	42,800	48.3	38
Professional and technical	8,550	12.2	13,200	14.9	54
Managers, officials, and proprietors	7,452	10.6	9,200	10.4	23
Clerical workers	10,667	15.2	14,600	16.5	37
Sales workers	4,456	6.3	5,800	6.5	30
Blue-collar workers	25,534	36.3	29,900	33.7	17
Craftsmen and foremen	8,986	12.8	11,400	12.8	27
Operatives	12,924	18.4	14,800	16.7	15
Nonfarm laborers	3,624	5.2	3,700	4.2	a/
Service workers	9,256	13.2	12,500	14.1	35
Farm workers	4,444	6.3	3,500	3.9	-21

Source: National Commission on Technology, Automation and Economic Progress, Technology and the American Economy, Appendix Vol. I.

a/ Less than 3 percent.

Note: Projections assume a 3-percent level of unemployment in 1975. Percents to not add to totals due to rounding.

The demand for workers with high levels of education and skill will rise, and employment opportunities for the unskilled will narrow, continuing the trends of the recent past.

Professional, technical, and kindred workers have been the fastest growing occupational group. By 1975, the number of these workers needed may increase by more than two-fifths, considerably higher than the increase projected by the Bureau of Labor Statistics for all occupation groups as a whole. All other white collar workers are also expected to experience increases, although not as substantial.

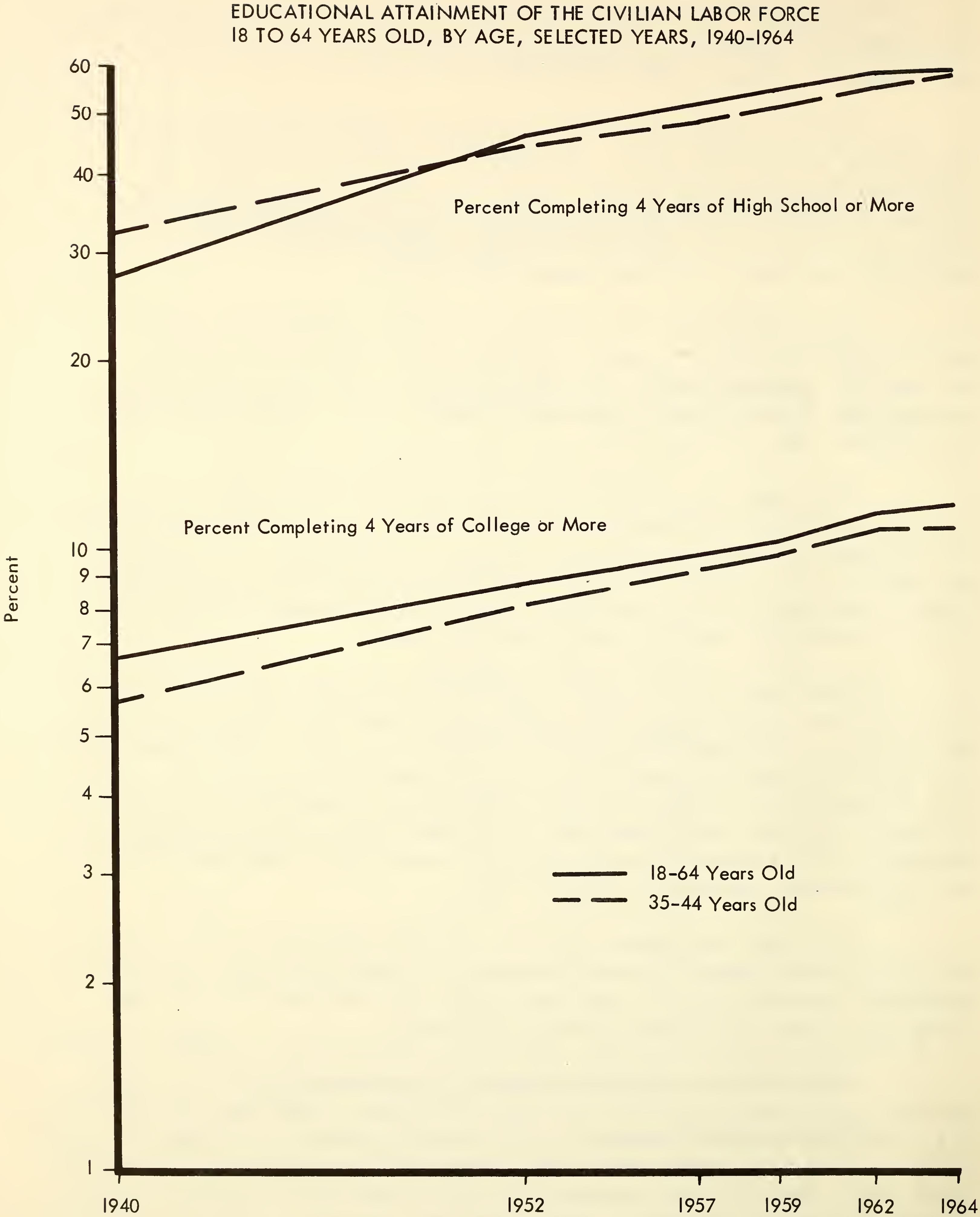
The requirements for craftsmen, foremen, and kindred workers will continue to show the largest increase among blue collar workers. The need for semi-skilled workers is expected to grow at a slower-than-average rate in the future. Increasing technological advance will tend to eliminate some of their jobs.

The number of unskilled laborers has been declining over the past few years and will continue to do so. This is due to the replacement of this type of worker by machinery such as in excavating, ditch digging, and similar work. Also, integrated systems of processing and materials handling equipment, which represent a more advanced stage of automation, will be installed in an increased number of plants.

This trend toward higher educational and skill levels of the work force has been going on for a long time. Impressive gains have been made in the educational attainment of workers since 1940. The proportion of workers who have completed four years of high school or more has risen from 32 percent to 57 percent, while the proportion with four years of college or more has risen from below 6 percent to over 11 percent (see Figure 6). The workers in every major occupation group have shared in this educational upgrading (see Table XII).

The Labor Department has also concluded that graduates of post-secondary preemployment training programs are expected to have excellent employment opportunities, as are individuals with specialized training other than formal vocational education programs.

The importance of these programs is reflected by the increased activity on the part of groups actively advocating, promoting, and conducting vocational/technical programs. For example, community colleges or junior colleges are being established throughout the country at an extremely rapid rate. Many of these institutions offer vocational training programs as well as academic programs. Some of the new colleges or training centers result from community efforts; others are more regional in nature.



Source: Johnston, Denis F. "Educational Attainment of Worker, March 1965," Monthly Labor Review Vol. 88, No.5, May 1965, p.518.

Figure 6

TABLE XII

PERCENTAGE OF MALES AGE 25-29 WHO HAVE COMPLETED 12 YEARS OR MORE OF SCHOOL, BY MAJOR OCCUPATION GROUP, UNITED STATES, 1940, 1950, AND 1960

Major Occupation Group	1940	1950	1960
Total	38.8	50.6	60.0
Professional, technical, and kindred workers	90.7	93.0	95.4
Managers, officials, and proprietors, except farm	67.4	74.0	81.2
Clerical, sales, and kindred workers	68.4	75.6	80.0
Clerical	-	75.2	78.6
Sales	-	76.1	81.8
Craftsmen, foremen, and kindred workers	36.5	49.3	55.9
Operatives and kindred workers	27.5	33.3	39.7
Service workers	33.1	43.7	52.5
Farmers, farm managers; farm laborers and foremen	16.3	29.1	41.6
Farmers and farm managers	18.9	33.5	58.7
Farm laborers	13.1	21.2	21.8
Laborers, except farm and mine	18.5	23.1	29.6

Source: Cowhig, James D., and Calvin L. Beale, "The Rising Levels of Education Among Young Workers," Monthly Labor Review, Vol. 88, No. 6, June 1965, p. 626.

The Upper Midwest Research and Development Council, for example, has assisted the State of Montana in exploring the problem, and the Southern Regional Education Board has been investigating the community college question in the southern states. Kansas is in the process of establishing a number of regional vocational training centers, as are several other states.

While the technical-vocational program has many benefits and an important role to play, it is not the entire answer to the technical manpower problem. A study by Edwin P. Estle concluded "that industry does not rely on the vocational system for providing fully trained workers.... Training in vocational schools can only provide a foundation but a very helpful one -- for specialized on-the-job training."1/ Nevertheless, vocational training has an important place in any regional development program.

Creating a General Public Awareness

An equally important factor is the local climate or environment for technological development -- reflected by a general public awareness of the need for and potential offered by upgrading the level of technological activity in the region. Many organizations include stimulating a public awareness of science and technology among their objectives. For a few, such as Frontiers for Science in Oklahoma and the Southern California Industry Education Council, it is a primary goal.

The basic stimulus to the formation of these groups is the need to awaken the area to the changing times and the importance of science and education in these changes. Their specific objectives usually include improving education, increasing the public awareness of science and technology, and increasing research in their area. The underlying goal, of course, is to stimulate economic growth of the region by developing and attracting science-based activity.

The activities of the Frontiers of Science illustrate how these organizations operate. Some of the early programs included seed money grants to finance the Oklahoma City Educational TV station in its early years, for the Oklahoma State University's traveling science laboratory which tours the state, and for an Oklahoma University computer layout study.

1/ Estle, Edwin F., "The Role of Public Vocational Education," New England Business Review, January 1967, p. 6 (20).

In the education area, the organization has conducted a statewide aptitude test for 60,000 students; they have been instrumental in introducing the modern math curriculum and are now doing the same thing with the modern science curriculum.

One activity -- employed successfully by many of these groups -- is the sponsorship of seminars or symposia. Presentations by prominent scientists to high school students create an awareness and help to arouse their interests in scientific fields.

Results from this approach to upgrading regional technology do not appear overnight. Yet it appears to offer potential. Focusing attention at the elementary and high school level should, over the long run, be instrumental in creating the climate needed to upgrade technological activity in the region.

B. The Role of Research

Many consider research the key to regional economic development, and a variety of approaches have been followed in an attempt to increase the amount of research being conducted in the region as well as to focus research efforts on regional problems. This section of the report describes some of the alternative forms of action being employed.

The Research Institute

Some 12 to 15 research institutes have been established throughout the country -- a principal motivation being to help stimulate the economic development of the region. The purpose of this section of the report is to explore the rationale underlying formation of research institutes, to describe the types of functions an institute can perform, and to identify some of the factors which influence the success of this approach as a means of stimulating regional growth.

Underlying motivation: Regional economic development has been a principal motivation underlying the establishment of research institutes. Research institutes are usually "formed by groups of regional business leaders who recognize the need to apply science and technology to build up industry, to increase productivity, and to contribute to regional growth

and problem solving."[1] These local business leaders are convinced that a center for research in the area will help to upgrade the level of technology of local industry, thereby encouraging industrial expansion and economic growth.

Functions: The research institute performs several important functions. It provides research assistance to help solve the immediate, practical problems of industry and federal, state, and local government. It is a source of new ideas, products, and processes which aid in the development of individual corporate and government enterprises. It helps to train business and government leaders in the use of new planning and management techniques. And it serves as a training ground for technical and management personnel.[2] An example of the importance of this training function: over 2,000 Mellon Institute alumni now hold responsible R&D positions in industry. Similar experience could be cited for the other institutes.

Role in regional development: A research institute contributes to the development of a region by providing a source of employment for scientists, engineers, technicians, and others employed by the institute itself. And, the multiplier effects influence the rest of the community just like any other local industry. Moreover, because of the type of personnel employed by the institute, income levels are relatively high.

The institute helps to expand the local pool of technical manpower for local industry, as well as new industry. (This training function is often cited as one of its more important roles.) Expansion of the scientific community is extremely important from the standpoint of recruitment, because scientists seek employment in an environment which offers opportunity for association and exchange of ideas with others of similar interests. When Midwest Research Institute was established in 1944, only a small number of people were engaged in research and development in the Kansas City area. Today the scientific community numbers about 7,000. The presence of MRI has undoubtedly had an influence in this growth.

The research institute stimulates local industrial growth. Certainly, many of the research institutes were established to aid medium and small businesses in their areas, and there is no doubt that hundreds

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1/ Kimball, Charles N., Statement before the Special Subcommittee on Scientific Manpower Utilization of the Senate Committee on Labor and Public Welfare, January 26, 1967.

2/ Hobson, Jesse E., "The Nonprofit Research Institute in the United States," Mimeograph, undated.

of local companies have benefited. Yet most of the industrial research conducted by the institutes has been done for major national firms with headquarters elsewhere, simply because there is not sufficient business within the region to support a research institute.

Numerous examples can be cited of the work done by research institutes for small- and medium-sized companies. Midwest Research Institute, for example, began working in 1958 for a small pharmaceutical firm, doing all of its early research. Today that company's sales have reached $10 million and are growing at a rate more than twice the industry's; it now has its own research capabilities.

The recent industrial expansion around the Research Triangle Institute provides another example of the effect an institute can have on the industrial development of the region. "Since mid-1966, employment has risen from less than 1,000 to around 5,000"[1/] in the associated Research Triangle Park.

While research institutes do promote industry, this does not necessarily help the region in which the institute is located. Donald W. Taylor, in his study of the role of the research institute, cites the following example.

> "Battelle has been outstanding among the independent institutes in conducting research leading to the development of new industry. Perhaps its most notable achievement was the development of the process which led to the creation of the Xerox Corporation. This company, however, is located not in Ohio but in Rochester, New York."[2/]

The research institute serves local and state government, and in this regard the institutes have contributed materially to the state and local planning and development programs. Yet the greatest percentage of their government work has been for the federal government. From his study of research institutes, Taylor concludes that "the work done for some agency of the (federal) government varies from more than 80 percent to not less than 50 percent."[3/] Although the application of technology to civilian needs has been a major goal of the research institute, a large part of the work sponsored by the federal government is for the Defense Department.

1/ "Research Park Thrives in Academic Neighborhood," Business Week, December 10, 1966, p. 185.

2/ Taylor, Donald W., Should a Not-for-Profit Research Institute be Established in Connecticut, Yale University, New Haven, Connecticut, 1965 (73).

3/ Ibid., p. 11 (73).

The research institutes have generated numerous "spin-off" enterprises. These range from private R&D and consulting organizations established by former institute employees to production activities capitalizing on new products or processes. "More than 25 new companies have come directly from SRI, primarily through SRI-trained researchers leaving to establish their own enterprise."1/ Another good example of spin-offs is in the case of Cornell Aeronautical Laboratories at Buffalo, New York. "One of the spin-offs of CAL has been Moog Servo Control Company at East Aurora, New York, with 1,500 people, now larger than CAL itself."2/ However, these new science-based industries do not necessarily locate (and, therefore, do not have a direct impact) in the region in which the institute is located.

Considerations in establishing a research institute: In exploring the merits of establishing a research institute as a device to encourage regional economic development, a number of factors should be examined. Taylor3/ lists nine objectives often given for the establishment of a research institute. (These are listed in decreasing order of probability of achievement.)

1. Provide a payroll with attractive work and salaries.

2. Conduct research for the federal government.

3. Conduct research for large companies regardless of their location.

4. Improve the image of the state and the cultural and intellectual atmosphere of the immediate area.

5. Conduct research for state and local governments.

6. Conduct educational activities of benefit to state industries.

7. Conduct research for medium- and small-sized companies within the state.

8. Attract industries to locate within the state.

9. Create new industries within the state.

1/ *Op. Cit.*, Hobson, p. 3.

2/ Kimball, Charles N., Statement before the Department of Commerce State Science and Technology Conference, Washington, D. C., February 3-4, 1964.

3/ *Op. Cit.*, Taylor, p. 2 (73).

Taylor concludes that a research center should be established only if its founders' objectives are among the first four listed above.

The point is that a research institute can contribute only so much to the economic development of its region. Other types of institutions and action forms may be more effective.

Nor, do we need 50 research institutes, each oriented to its own state. The extent to which a research institute can maintain its strong regional orientation is limited. In Rhode Island the approach of establishing an institute which concentrates on a specific field -- design -- has been followed. Other fields such as oceanography, metallurgy, mineral resources, etc., suggest types of specialized fields which might conceivably support a special-purpose research institute.

The factors which determine the success of a research institute are essentially the same as for any other science-oriented activity. Because the research institute requires large numbers of highly competent scientists, engineers, and other professional people, the location constraints are similar to those confronting any other research and development activity.

A research institute can play an important role in the economic development of a region. But, like the university, the institute alone will not assure economic growth and progress for the region.

State Research Agencies and Commissions

Officials of most states recognize that science and technology will play a vital role in shaping the course of future development. They see the need to respond -- to establish mechanisms to insure that their state will keep up (or catch up) with the tide of technological advance. A variety of approaches or mechanisms, ranging from science advisory committees to state research agencies, has emerged.

The State of Pennsylvania, for example, established the Governors' Council of Science and Technology in 1963. This group, comprised of educators and business leaders, was charged with the responsibility "to develop and implement programs to accelerate the growth in Pennsylvania of new science-oriented industries."[1] Specifically, the Council was asked to:

1/ Science and Technology: Generators of Economic Well-Being, Report of the Governors' Council of Science and Technology, Commonwealth of Pennsylvania, September 1964, p. 3.

1. Prepare inventories of relevant personnel and facilities and natural resources to be used in the sales and service effort directed toward the science-oriented industries.

2. Provide a sales resource for direct solicitation of industries in the technological field.

3. Develop recommendations for state educational policies in the areas of scientific, technological, engineering, and related vocational education at all levels leading to the establishment of an optimum system meeting the new industry requirements.

4. Based on existing and planned resources, identify the areas of science and technology which represent Pennsylvania's greatest potential.

5. Suggest ways to improve the climate for the production and commercial exploitation of new ideas in science and technology.

6. Develop mechanisms which will systematically bring together venture capital, management skills and new inventions and technology.

7. Facilitate and develop procedures which will bring about greater coordination between industry and pure research of universities and nonprofit corporations.

8. Inform the general public and educational leaders of the vital role of science and technology in the economic life of Pennsylvania.

9. Develop and implement programs for the establishment of science research complexes combining the total resources of industry, government and education, centered in our major university areas.

10. Recommend ways in which atomic energy activities and new technologies may more fruitfully be developed and coordinated in Pennsylvania, and private enterprises in these fields more effectively encouraged.

11. Review Pennsylvania's laws, regulations, and procedures from time to time to assure that they meet the new opportunities and conditions in ways that will encourage the development of the new technologies, while fully protecting the interest, health, and safety of the public.

12. Assure the coordination of the studies and actions thus undertaken with other atomic energy and technological development activities, public and private, throughout the United States.

13. Draw on local civic initiative -- forming regional committees, integrating them in overall state goals.

14. Mobilize state and political support for procurement of federal programs for Pennsylvania.

Committees were established to follow through on these tasks. A similar approach has been followed in other states.

The State of Kansas has responded somewhat differently. The Kansas legislature in 1963 established the Research Foundation of Kansas. This nonprofit institution has the following objectives:

1. To encourage and promote expansion, acceleration, and development of the state's research activities in all fields of intellectual endeavor and improve the efficiency of such programs.

2. To encourage and promote broad programs for the transfer of the results of research to the economy of the state.

3. To coordinate the research efforts of the colleges and universities, state agencies, and private research institutions insofar as practicable.[1/]

Emphasis of the Kansas Research Foundation is on increasing the amount of research conducted in the state and on facilitating the transfer of research results to Kansas industry.

The Connecticut Research Commission takes a somewhat broader view. This group is concerned with "The identification of problems relevant to the economic growth of a state which require research in the natural sciences, the social sciences, the life sciences, engineering or the humanities and to initiate and support this research in either the public or private sector."[2/] Priority is given to:

> "Analysis of the strengths and weaknesses of human and materials resources upon which future economic growth would be built. Analysis of the changing demands and growth

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1/ Research Foundation of Kansas, First Annual Report, January 1, 1966.

2/ Malone, Thomas F., "Toward a Strategy for the Application of Science and Technology to Economic Growth," Presented at the 7th Meeting of the Panel on Science and Technology, Committee on Science and Astronautics, U. S. House of Representatives, January 25-27, 1966 (79).

opportunities for goods and services appropriate to the socio-economic stage of development of our state, in our markets and other states, and in our international markets. Analysis of those areas of science and technology from which it is likely that new knowledge and new techniques responsive or anticipatory to the demands for goods or services may emerge. Analysis of the entire process by which economic growth is related to science and technology."[1]

Thus, the Connecticut Research Commission views its job as encompassing investigation into the basic needs and resources of the state and the role of technology in the development of those resources.

Quite a different approach has been followed by the State of Nebraska. Recognizing that its abundant agricultural production is one of its strongest assets upon which to build future economic activity, the state established the Nebraska Agricultural Products Research Fund Committee, operating under the Department of Agriculture and Economic Development. An objective of this organization is to develop new technology leading to new market outlets for farm crops. For example, the Committee has sponsored research leading to the development of water-soluble packaging films made from starch. A major chemical company has been issued a license to use the process and has located a plant in the State of Nebraska for production of the film. This has resulted in new capital investment and employment opportunities in the state. A number of other products have also been developed as a result of research sponsored by the Committee. Again, the basic objective is to stimulate economic and industrial growth in the state through research.

Still another approach employed is that found in the State of Mississippi. The Mississippi Research and Development Center was established by an act of the state legislature in 1964 in order to raise the standard of living in Mississippi. The staff of the Center does the actual analytical work necessary in order to achieve its objectives. The Center's activities include work in the following areas.

1. Market Analysis
2. Management Services
3. Community Development
4. Information Services
5. Computer Facility
6. Manpower Resources

1/ Ibid. (79).

C. Technical Assistance

Although much effort is devoted to attracting new science-based undustry, it is likely that most growth will come from within -- from the expansion of existing industry. Thus, a number of technical assistance programs have been established with the objective of aiding and upgrading existing industry.

The Engineering Experiment Station

State university engineering experiment stations vary widely, although each has the function of assisting industry in its state.

At Georgia Tech, for example, the engineering experiment station has an industrial development division with a staff of 70. Activities range from market research and feasibility studies to technology transfer activity under the State Technical Services Act. A number of field offices have been set up. The Georgia Tech program is often cited as one of the most outstanding and successful programs in the country.

Other states are expanding their engineering extension activities. Iowa State University in 1963 established the Center for Industry Research and Service (CIRAS). The basic function of CIRAS is to provide a referral service -- to place the industry or business with a problem in touch with the service agency or consultant (engineers, architects, testing laboratories, advertising agencies, etc.) which would be best able to deal with the problem. In addition, CIRAS administers the state technical services program for the state as well as other related programs such as the inventors and innovators program. A field staff maintains close contact with business and industry to assist in identifying problems and finding solutions.

A similar program in Tennessee (TIRAS) has recently been expanded to include a technical information dissemination service. This same technology transfer activity is being expanded at a number of other universities.1/

1/ For a complete list of state information dissemination programs see U. S. Department of Commerce, Office of State Technical Services, First Annual Report, 1966, pp. 42 - 44 (86).

Engineering extension and experiment station programs focus on aiding and upgrading business and industry in the state. Because of their work and experience in this field many of the universities having these programs have been chosen to administer the State Technical Service program in their respective states.

State Technical Services

The growth in both public and private research and development activity has resulted in the generation of scientific and technical knowledge at a phenomenal rate. This reservoir of knowledge has stimulated growth of existing industries and has helped to develop entire new industries. Yet this ever increasing store of knowledge is undoubtedly a grossly underutilized national resource. The purpose of the State Technical Services Act of 1965 is to help speed the development and spread of new technology, thereby increasing the rate of economic growth, creating new employment opportunities, helping to offset imbalances between regions and industries, aiding the international competitive position of United States industry, enhancing our national prestige, improving the quality of life and assisting significantly in filling unmet human and community needs.1/

Specific objectives of the program are:

1. To encourage the examination of technology and economic conditions state by state and to develop sound plans on a broad base of participation aimed at improving the local economy through the introduction and application of new science and technology.

2. To identify interstate, regional or national problems or opportunities of special significance and to develop action programs to resolve or diminish such problems or to capitalize upon the potentials of opportunities when identified.

3. To increase the ability of scientists, engineers, and business and industrial management personnel to acquire and make use of new science and technology by appropriate programs of continuing professional education.

1/ Ibid., p. 3 (86).

4. To encourage state-university-industry cooperation -- included in this objective are inter-institutional relationships and interstate activities -- and broaden the base of institutional participation in assisting local business and industry to apply new scientific and technological discoveries to their own purposes.

5. To increase the ability of industry broadly to gather and assimilate the pertinent aspects of the scientific and technical report literature for potential applications through the general introduction of many specialized techniques of literature search, abstracting services, microfilm techniques, computerized storage and retrieval of information, and making greater use of consultants and other locally available sources of expertise and information services.

6. To generate a complete exchange of information among the States concerning their respective technical services programs so that all participants may learn through the example of others.

7. To assist in the development of local, state, regional, and national resources, particularly in terms of bringing the best available skill to bear upon the problems identified throughout these objectives.

8. To encourage innovation and a greater application of science and technology as driving forces behind economic development.

9. To study the process by which technology is transferred, identifying those factors which assist and those which impede such transfer, and then developing more positive means of obtaining the desired objectives of technology transfer by participating in the establishment of linkages between the generators and the potential users of new knowledge.

10. To work with other governmental agencies at all levels, educational institutions, and professional and technical societies in achieving the above objectives, without overlap or gap, while bringing the best available scientific and technological resources, whether public or private, to bear upon each problem of commerce, business and industry that has been identified and for which solution is wanting.1/

1/ Ibid., p. 6 (86).

Each state has designated an agency to administer the program in the state. Although the programs vary from state to state, the activities fall into three general categories:

1. Preparing and disseminating of technical reports, abstracts, computer tapes, microfilm reviews, and similar scientific or engineering information, including the establishment of state or interstate technical information centers for such purposes.

2. Providing a reference service to identify sources of engineering and other scientific expertise.

3. Sponsoring industrial workshops, seminars, training programs, extension courses, demonstrations and field visits designed to encourage the more effective application of scientific and engineering information.1/

The State Technical Services program is too young for observers to evaluate its role properly in stimulating the regional advance of technology. However, it represents a major resource to be considered in any regional effort to upgrade the level of scientific and technological activity.

Other Federal Information Dissemination Programs

Several other federal information dissemination programs have basically the same purpose -- to provide scientific and technical information to those who can use this information. The programs of the Science Information Exchange, the Atomic Energy Commission, the NASA Office of Technology Utilization, and the Clearinghouse for Federal Scientific and Technical Information are summarized below.2/

Science Information Exchange: This program, funded principally by the National Science Foundation, is administered by the Smithsonian Institution. Its primary task is to develop and maintain an inventory of current and ongoing research projects. It was established initially to help R&D program managers in federal agencies avoid duplication, establish priorities, maintain balance among related research fields, locate special research capabilities, and perform other useful tasks. However,

1/ *Ibid.*, p. 6 (86).

2/ For a more detailed discussion of these programs see Lesher, Richard L., and George J. Howick, *Assessing Technology Transfer*, NASA Office of Technology Utilization, 1966 (35).

information is available to any qualified scientist or engineer regarding research under way in specific fields of interest. Thus, it serves a referral or clearinghouse function.

Atomic Energy Commission: The AEC has always had a program for disseminating nonclassified information to industry. This information transfer activity was expanded recently with the formation of the Office of Industrial Cooperation. Its functions are:

1. To actively search for items of information and disseminate this information to industrial organizations;

2. To be aware of the needs of particular sections of industry;

3. To encourage the industrial participation program;

4. To arrange industrial consultation and visits by industry representatives; and

5. To work with such local organizations as now exist which will be suitable for its general purposes.1/

Mechanisms used include publication of topical reports, participation in technical meetings and publication in technical journals, publication in trade journals, seminars and information meetings, operation of 12 specialized information centers, provision of consulting services, encouraging industry to utilize AEC facilities, under certain conditions allowing individuals and companies access to classified information, news releases, and other mechanisms.

NASA Office of Technology Utilization: Like the AEC, NASA is encouraging the use by industry of technology developed as a part of the space research program. Basic elements of the NASA program are: "(a) identification of industrially relevant new technology; (b) evaluation of that technology to determine its significance and import; (c) publication of especially useful new information in industrially oriented language and format; and, (d) dissemination of the information via traditional means and via regionally deployed contracting organizations (universities and research institutes) which match the new technology to the needs, interests, and objectives of organizations in their regions."2/

1/ Ibid., p. 59 (35).
2/ Ibid., p. 66 (35).

Each of NASA's eight experimental regional dissemination centers offers a variety of services to private companies in their region. Professional personnel in the regional dissemination centers help company personnel define problems and objectives. They assist in searching for information which might be of value. In addition, the regional center disseminates on a selective basis information to area industries. The regional dissemination centers also sponsor conferences and seminars and experiment with other techniques of technology transfer.

The Unknowns in Technical Assistance: A large number of programs have been established at the federal and state levels to facilitate the flow of scientific and technical information from research laboratory to business and industry. The assumption is that overt efforts to transfer technology will result in the acceleration of the transfer process. Yet surprisingly little is known about this extremely complex process. As we gain experience with the various technical assistance and technology transfer programs we should learn more about what seems to work and what doesn't, what conditions are most conducive to acceptance of new technology, and what are the primary barriers which must be overcome in order to increase the effectiveness of our technical assistance programs. Answers to these questions can only be obtained through continued research and experimentation.

D. Planning and Promotion

There are hundreds of regional, state, and local planning and development organizations, many of which are concerned at least to some degree with science and technology. For example, the objectives of the Michigan Department of Economic Expansion include: (1) the encouragement of scientific research and the development of new and more extensive use of forest, mineral, and other resources through universities and colleges of the state, and public and private agencies; and (2) continuing research and recommendations of programs necessary to provide training for vocational skills.[1/]

Activities of these groups range from the traditional industrial promotion efforts to more sophisticated studies of specific regional problems or resources. For example, many of the state economic development departments have conducted inventories of R&D and related organizations in their states and have published brochures extolling the virtues of their states as locations for science-based industry. Others have gone so far as to make studies of the feasibility of locating or expanding specific science-based industries, such as electronics, in their states.

1/ Michigan Department of Economic Expansion, 1964 Report, p. 7.

Programs of these groups include seminars and conferences to explore ways to promote R&D and to attract science-based industry, technical assistance to local development groups in establishing research parks, encouraging and promoting the establishment of research institutes and other research centers in their area.

Other groups, such as the Upper Midwest Research and Development Council, focus attention on studying the problems and potentials of the region. Through its research, this group endeavors to provide a sound base of information and knowledge upon which to base action programs. The Council does not actively engage in industrial promotion activities but aids state and local development groups in their efforts.1/

It is difficult to evaluate the effectiveness of these planning, development, and promotion groups. However, because a number of these organizations are active in virtually every region, it will be important for the new regional commissions to become familiar with their programs and activities.

E. Financial Assistance for Science-Related Activity

The Need

In virtually every discussion of prerequisites for the development of a science complex or science-based industry one factor stands out as vital to success. There must be financial institutions attuned to the needs of R&D and science-based industry.

In most cases the research-based enterprise is very unlike those the financial community is used to dealing with. In the first phase, the new science-based firm is often trying to do something no one has done before -- to develop and market a new idea or product. As a result, there are often many unknowns regarding the market. Moreover, these new organizations are usually headed by technical people with little or no previous business experience, while the financial institutions seldom possess the technical expertise to evaluate these new ventures properly.2/

1/ Anding, Thomas, "Upper Midwest Research and Development Council: The Action Program," Paper presented at the 13th Annual Conference, Midcontinent Research and Development Council, September 26-27, 1966.

2/ "Where Does the Money Come From?," New England Business Review, January 1964, p. 6 (95).

The importance of a visionary financial community to the small research-based enterprise is easily seen. It is given much credit for the development of Route 128 around Boston. And Dr. Jesse Hobson, in speaking of the development around Palo Alto, California, noted that "adequate and ready money was ready for investment."1/

Dr. Jean Paul Mather, testifying before the Senate Committee on Labor and Public Welfare, stated that he had little difficulty in raising capital for a science center in Philadelphia but found a different financial climate in the Midwest. He concluded:

> "It is my own personal and professional opinion that one of the main obstacles to active research and development growth as well as the development of new industries in the Midwest, is the extremely conservative caution and almost reactionary policies of financial institutions in the area toward speculation or investment in innovation, invention, or the new products of the knowledge industry."2/

Some observers close to the problem support the view that the problem is not a lack of venture capital but only a lack of information regarding the availability of funds. The Department of Commerce Panel on Invention and Innovation concluded that "The alleged absence of potentially available venture capital is not really the problem" and recommended that "appropriate mechanisms should be developed to provide information on capital availability and the problem of new enterprise development at the regional level."3/ This view was also expressed in an article in the New England Business Review which noted that "The supply of funds available for all types of venture investments has never been greater."4/

Donald Schon, writing in the Harward Business Review, concluded that "However this argument is finally resolved, it seems clear that capital shortages are not the stumbling block for small business. And whether

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1/ U. S. Congress, Senate Select Committee on Small Business, The Role and Effect of Technology in the Nation's Economy, Part 1, 88th Congress, 1st Session, May 1963, p. 60 (83).

2/ U. S. Congress, Report of the Senate Committee on Labor and Public Welfare, The Impact of Federal Research and Development Policies Upon Scientific Manpower, 89th Congress, 2nd Session, December 1966, p. 39 (84).

3/ U. S. Department of Commerce, Technological Innovation: Its Environment and Management, January 1967, p. 43 (88).

4/ "Where Does the Money Come From?," New England Business Review, January 1964, p. 8 (95).

the need for easier risk capital is small or nonexistent, there is at least need for better information about it."1/ In fact, Schon has expressed the view, similar to that of the Panel on Invention and Innovation, that state agencies should consider establishing suitable financial information mechanisms as part of their programs to aid local or regional development.

The Sources

Shapero points out that the new research-based enterprise usually requires three types of financing, depending upon the company's stage of development: initial financing, interim financing, and growth financing. Initial financing is characterized by a firm "with no marketable product, working model, mock-up, or prototype, and there may not even be a design or any product specifications. The principal asset may consist of a new theory or idea that must be proved."2/ Interim financing, required when a firm has a marketable product but its retention of earnings has not been sufficient to rely on completely, usually involves short-term credit. The third phase, growth financing, occurs when a company is able to issue stock to the public. "This position occurs after a company has been in existence at least five years, when sales have exceeded $1 million, and when there have been some profitable years of operation."3/

The major source of initial capital for the new research-based enterprise is the individual investor.4/ The individual is not subject to many of the necessary constraints and regulatory measures which influence other sources. Moreover, the amount of capital needed is usually small. It has been found that "Typically, such an investor has himself been a technical entrepreneur at some time in his career. This fact is usually responsible for his wealth. It also explains his interest in new research-based venture investments and his emotional commitment to them, which may well outweigh the economic considerations involved."5/

1/ Schon, Donald A., "The New Regionalism," Harward Business Review, January - February 1966, p. 175 (60).

2/ Shapero, Albert, Kirk Draheim, and Richard P. Howell, The Development of a Potential R&D Complex, Stanford Research Institute, July 1966, p. 48 (64).

3/ Ibid., p. 50 (64).

4/ "Where Does the Money Come From?," New England Business Review, January 1964, p. 7 (95).

5/ Ibid., p. 7 (95).

The commercial banks represent a second source of funds. However, "except in special cases where they allow a line of immediate credit, banks are not an important source of venture capital."1/ On the other hand, the banks do represent a potential source of interim financing.

Another potential source of capital is the venture capital organization. In addition to the small business investment corporations, a number of private groups such as Vencap, Inc., and American Research and Development Corporation have been highly successful. However, according to a study sponsored by the Boston Federal Reserve Bank, "Very little initial financing is currently being obtained by entrepreneurs from the venture capital organizations...Their limited past experience proved that the risks and administrative costs of this first financing tend to offset the potential gain of getting in early."2/

Another more recent source, which may play a more active and important role in the future, is the established industrial corporation. It may have generated cash faster than opportunities for profitable reinvestment. Other motives may include the desire to attract qualified technical people, to gain access to new technologies, or to acquire an affiliate near a center of scientific activity.

During the growth stage, the firm may issue stock to obtain needed capital. However, "Public issues are not generally feasible while the firm is still small. For small offerings, costs will take a large percentage of the proceeds."1/ Thus, the firm will not usually attempt to go public until sufficient growth has taken place to warrant this move.

In some areas, development credit corporations have been established to supplement existing financial institutions. An example is the Regional Development Fund of the Regional Industrial Development Corporation of Southwestern Pennsylvania. The ultimate objective of the fund is to encourage industrial and scientific growth in southwestern Pennsylvania by making loans to new or expanding industry, "when and if such credit is not otherwise available from conventional lending sources."3/ In fact, many of the companies receiving loans have been referred to the fund by other financial institutions. The fund is closely related to the Southwestern Pennsylvania Industrial Development Corporation and calls on the RIDC's

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1/ "Financing the New Venture," New England Business Review, August 1958, p. 6.

2/ "Where Does the Money Come From?," New England Business Review, January 1964, p. 7 (95).

3/ RIDC Industrial Development Fund, First Annual Report, 1963, August 31, 1963, p. 1.

Scientific and Research Advisory Committee when considering loan requests requiring technical advice. The resources of the fund have been used to help establish a number of science-based industries in the region.

F. Sites for Science and Industry

In an effort to attract R&D organizations, many development groups have established research parks -- sites set aside specifically for research and development activities and science-related light manufacturing. The 1966 "Research and Science-Oriented Park Director", published by Industrial Research, lists over 100 such developments in the United States and Canada.1/ The list includes only those which are restricted to research activities or to organizations which can be classified as scientific enterprises.

The factors which are important in the location of R&D and related industries have been discussed in other sections of this report.2/ They are all basic to research and science-oriented industries regardless of whether the industry is located in a research park or outside.

The advocates of research parks believe that offering attractive well planned sites tailored to the needs of R&D will attract other science-oriented industries. R. John Griefen, in an article in Urban Land, aptly described one side of current thought (with which he disagrees) regarding research parks:

> "If an Industrial Park was a highly sophisticated form of land development for modern suburban land use, then wouldn't a research park, even more restricted, more landscaped and more refined, be an even more desirable park of the community development program? This thought has great appeal. It is easily sold to the community in application for zoning change.

1/ "Research and Science-Oriented Park Director," Industrial Research, May 1966, pp. 45 - 50.

2/ For a further discussion of these factors see "Research and Science-Oriented Park Director," Industrial Research, May 1966, pp. 45 - 50, J. J. Ritterskamp, Jr., "Economic and Industry Effects from Research," Paper given at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963, pp. 7 - 9 (56); and "Research Park Thrives in Academic Neighborhood," Business Week, December 10, 1966, pp. 185 - 188. ✓

It appeals to the people to whom 'Industrial' is a dirty smoke-belching word. It is currently sophisticated, and perhaps above all, it is patriotic."1/

However, in spite of the appeal of the research park concept, communities have found them, in general, to be an unsuccessful experience.2/ In fact, for even the more successful parks such as the Stanford Research Park success did not come overnight. "The park was not a runaway success at first."3/ "Research parks are notoriously slow starters. In such cities as Atlanta, Detroit, and Ann Arbor park projects have lagged."4/

The evidence suggests that the business community is not willing to buy the research park concept. According to Griefen, research groups desire to be alone -- on their own land. Moreover, they prefer a greater land-to-building ratio (10 to 1) than the 2 to 1 or 3 to 1 offered in research parks. They do not need to be on major highways, and are very often located in or near residential areas. For some firms a research park may not be suitable because of the desire to locate the research function near corporate headquarters -- an important factor in many decisions. This also allows the company to use the research facilities as a showcase. An example of this is the Pennsalt Technical Center in King of Prussia Park outside of Philadelphia.

While many research parks have not lived up to expectations, some have been highly successful. For example, Technology Square in the Cambridge area has two buildings with 325,000 square feet completely leased. Plans are now being made for a third building. And, after a slow start, employment at the Research Triangle Park has risen from less than 1,000 to around 5,000 since mid-1966, with invested capital rising from $10 million to a figure near $65 million. The Stanford Industrial Park includes about 400 developed acres. Located there are 43 firms, most of them electronics-oriented firms, employing over 11,000 people.

If these research parks have been such a success, why are others lagging? Many of the other attempts are also located near strong science-engineering universities and possess the attributes often considered to be essential.

1/ Griefen, R. John, "A Research Park Does Not Live by Research Alone," Urban Land, Vol. 24, No. 3, March 1965, p. 3 (23).

2/ Allison, David, "The University and Regional Prosperity," International Science and Technology, April 1965, p. 23 (1).

3/ "Stanford: Boom in Electronics in the Bay Area Was Ignited Down on 'The Farm'," Science, Vol. 143, 20 March 1964, p. 1307 (71).

4/ Op. Cit., Business Week, p. 185.

One problem, according to some observers, has been the attempt to develop a strictly research park. For this type of development to be a success the park must allow more than just research facilities. "Only when light manufacturing, prototype production and offices are included in the permitted uses have these research parks been successful."1/

Another problem facing the developers of research parks is the desire of management to keep their research facilities on a site by themselves. Reasons for this vary. Some companies want to make their research facilities a showcase clearly identified with the company. Others want their technical personnel protected from piracy. Many "want extreme security and feel this is more important than the cross fertilization among many scientific minds in a mixed-plant complex."2/

Many industrial developers acquired land and called their developments research parks only to find that they could not attract tenants; perhaps because the basic prerequisites for attracting science-based activity are lacking. There may be other reasons. And it may be that the critics are expecting to see results overnight when, in fact, the development process is usually quite slow. Regardless of the reason, research parks, as an element of industrial development strategy, have not proven to be as successful as originally anticipated.3/

1/ Op. Cit., Griefen, p. 3 (23).
2/ Ibid., Griefen, p. 5 (23).
3/ "The Changing Research Park," Industrial Research, May 1966, pp. 41 - 44.

V. IMPLICATIONS FOR THE REGIONAL COMMISSIONS

There is little doubt in the minds of most development officials that the level of scientific and technical activity in any region, particularly a lagging region, must be upgraded if that region is to improve its economic status. In fact, the region which fails to accomplish this can expect its economic development problems -- as reflected in low incomes, underemployment, and outmigration -- to intensify. We will never be able to blanket the nation with scientific complexes of the Boston Route 128 or San Francisco Bay Peninsula variety. Yet, unfortunately, most of the literature which has shaped the thinking about science and technology is keyed to these two areas.

Each region has certain strengths and weaknesses; some unique, others universal. Regions that grow and prosper capitalize on their strengths and overcome their weaknesses. For one region, this may mean building a cyclotron. For another it may mean reorienting and greatly expanding its vocational training programs. For a third, it may mean focusing R&D efforts on upgrading forestry practices and wood products technology in order to develop unutilized area resources. Unfortunately, there are no simple solutions.

Figure 7 illustrates, in a general way, the types of regional institutions or action forms which have been used in an effort to achieve specific regional objectives. Several alternative forms of action may play a role in achieving a particular goal or objective.

We know, for example, that a strong university can contribute to local and regional scientific activity in a number of ways. In fact, most observers consider a good university to be essential to the development of a scientific complex. Figure 7 illustrates the variety of regional organizations which can help to strengthen area universities.

One approach is the university association or consortium. By combining resources -- funds, facilities, and talent -- area universities can often accomplish things beyond the power of each operating independently. Joint academic programs, joint research programs, and the sharing of facilities and outstanding personnel are just a few examples.

State and regional research foundations and commissions can also play a role by identifying needs and problems, by helping to strengthen relations between the university and the area business community, and by helping to obtain funds from public and private sources to support university programs.

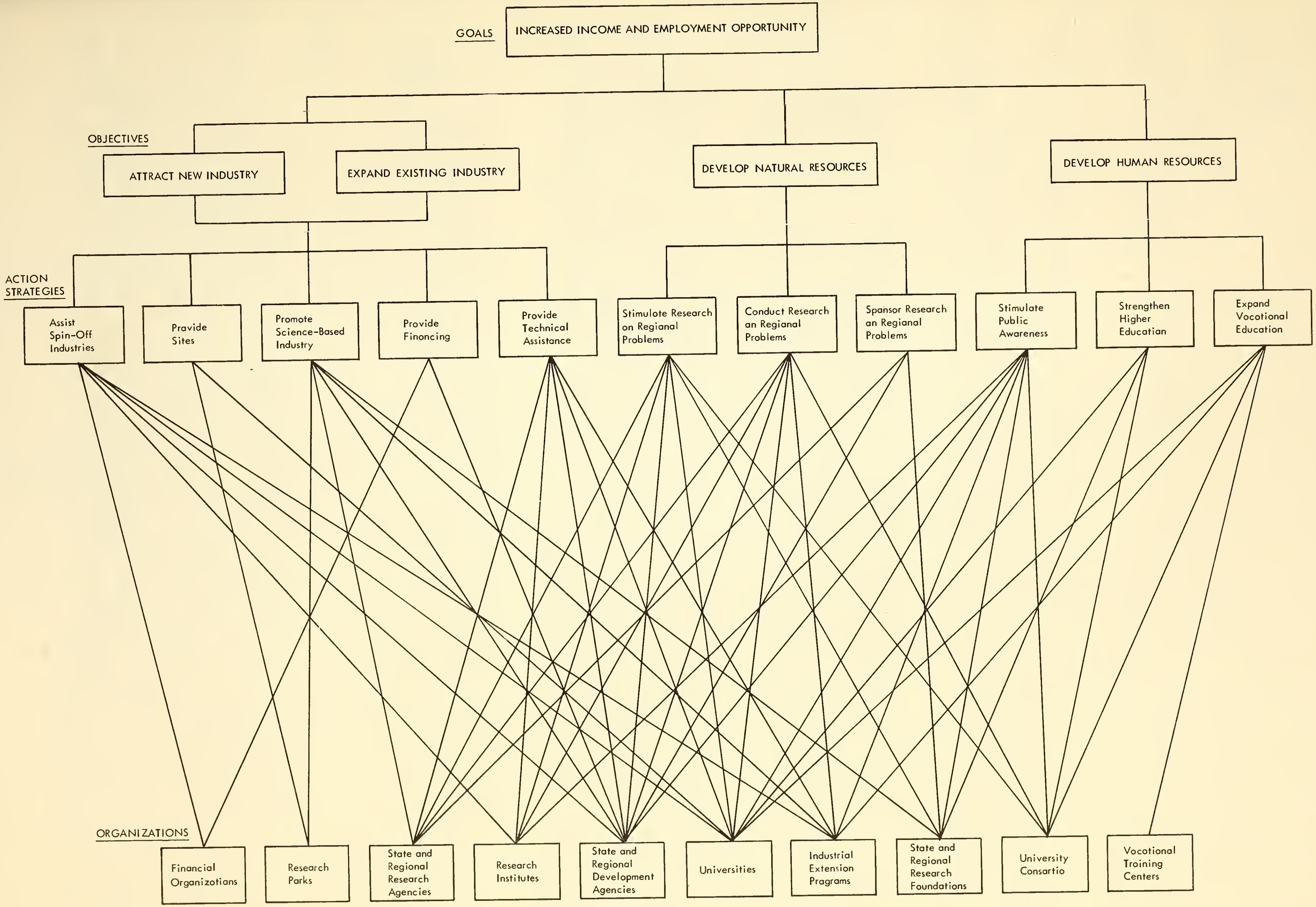

Figure 7 - Organizations and Action Strategies: Conceptual Interrelationships

Of course, much of the responsibility for enhancing the university's role in regional development lies with the university itself, which must be responsive to the needs of business and industry in the region. Policies which encourage consulting by faculty members, which facilitate use of university facilities by industry, which allow for special programs tailored to the needs of industry in the region, and which, in general, demonstrate a genuine interest in encouraging regional economic development are needed if the university is to maximize its potential role in the region.

Availability of technical manpower is another key factor influencing the pattern of regional economic growth, whether we are talking about a research laboratory or a fertilizer plant. Again, a number of alternatives can contribute to upgrading the skill level of the area's work force.

By the same token, a number of alternative measures can be taken to help upgrade the technological level of area industry. The university can play an important role in assisting local industries if it is oriented in that direction and has established the programs and mechanisms needed to provide technical assistance. The nonprofit research institutes offer another source of technical assistance for industry within a region. This institution, like the university, can assist in a number of ways, ranging from advice on new technology to research and development of new products and processes. State research agencies, state technical services agencies, industrial extension, federal information dissemination centers, and state and regional development agencies are among the other types of organizations which can be instrumental -- each in its own way -- in upgrading the technology level of area industry.

The task of the regional planning and development organization, therefore, will be to identify each of these institutions and relate its programs and activities to the region's needs, resources and goals. Any effort to establish new institutions or programs without first assessing those already in existence is likely to lead to a misallocation of resources.

One specific regional objective will be more responsive to one type of action form than another. Many factors need to be taken into account in selecting a specific course of action. For example, what level of capital investment is required, what sources can be tapped, and what effect will this investment have on other regional requirements? What is the likelihood of success -- i.e., to what extent is this action form likely to achieve the specified objective? What is the payoff period -- i.e., will there be immediate benefits or are the results likely to occur in the long range future?

For instance, adequate vocational training and other continuing education programs are often prerequisites for regional advancement in science and technology. Since the "lagging" regions tend to have lower skill levels in their work force than the more advanced regions, this type of program may be very appropriate for the "lagging" regions, and the impact on development of the region may be significant. On the other hand, the investment required to establish and maintain these important programs is likely to be high. And, the "payoff period" -- the time it takes to achieve major results -- is likely to be relatively long, although some positive results would appear almost immediately in the form of workers with new or upgraded skills.

This investment must be weighed against alternatives, such as a promotional program to attract science-based industry. In this case, promotional programs may be helpful but not essential for regional advancement. If successful, however, these efforts could have a significant impact on the development of the region (as measured in terms of new jobs). On the other hand, the probability of success -- the likelihood of attracting a large technology-oriented industry to the area -- is relatively low. However, the investment required to carry on a promotion program is relatively small compared to the requirements for some of the other alternative actions.

Clearly, the decision is not as simple as vocational training versus industrial promotion. All of these action programs must be present in one form or another if the level of scientific and technological activity in a region is to advance. The decision is how to allocate limited resources among a number of alternatives in order to achieve maximum results -- in order to best satisfy the development objectives for the region.

In conclusion, an overall strategy to mobilize the forces of science and technology toward regional development would consider the following elements:

1. Regional development goals need to be specified to permit judgments about the allocation of resources.

2. The Regional Commissions can identify problems relevant to the development of the region and its subregions. They can isolate further research required in the various scientific disciplines. They can initiate and support this research themselves or act as a catalyst in seeing that other segments of the public and private sectors address their resources to significant problems and opportunities. This last role of insuring interaction among the private sector, the public sector, the academic community and the research community is of vital importance.

3. A series of analyses which should receive primary attention early in the formulation of development program strategy are:

a. Analysis of the region's strengths and weaknesses to include its human and material resources.

b. Analysis of changing regional and national demands and opportunities for growth in relation to the stage of development of the region.

c. Analysis of those areas of science and technology from which the knowledge and techniques required to supply new goods and services may emerge.

d. Analysis of the interfaces between science and technology and economic development.

4. A corollary effort to identify other groups or organizations in the public, private, and academic communities, to reduce duplication, provide a means of blending their activities, and to identify those warranting special support.

5. The program should encourage and support research, development, and innovation in those areas identified by the analytical studies as vital to the region's development. These efforts might take the form of direct support by the Commissions or assistance in obtaining support from other public and private sources.

6. Lines of communications must be opened and maintained among institutions, individuals and companies whose activities are generally aligned with the goals established for the region.

7. No development strategy can insure that growth will occur. The effectiveness of any strategy is ultimately dependent upon the actions of individuals.

APPENDIX A

ANNOTATED BIBLIOGRAPHY

A large number of books, articles, government documents and reports, and other materials were examined during the course of this study. We have described and summarized this material on the following pages.

The bibliography entries are presented alphabetically by author. Each entry has been numbered. This number is presented in parentheses in the text of the report whenever the document has been cited. In addition, each reference has been coded to indicate the general coverage, as follows:

A. Impact of Science and Technology -- e.g., basic studies of relationship to economic growth.

B. Research and Development Patterns -- e.g., studies describing geographic or industrial patterns of R&D.

C. Manpower -- e.g., studies covering technical manpower needs, vocational training, etc.

D. Location Factors -- e.g., surveys of location requirements as well as studies of specific factors.

E. Action Programs -- e.g., descriptions of regional action programs to upgrade level of technology, attract R&D, etc.

F. Other -- materials which do not logically fall under one of the other categories.

The following chart provides an easy reference to the bibliography. The number in the left-hand column is the number of the entry. This is followed by the title of the report or article (sometimes abbreviated) and the number of the page on which the entry appears in the bibliography. The remaining columns indicate the general coverage of the report or article.

These brief synopses should enable the reader to identify the publications which appear to be of particular interest and which warrant more thorough examination.

GUIDE TO BIBLIOGRAPHY

No.	Page	Title	Impact of S&T	R&D Patterns	Manpower	Location Factors	Action Programs	Other
1.	80	The University and Regional Prosperity				■	■	
2.	80	Boulder Space Age Boom	■			■		
3.	81	Whither Graduate Education			■	■		
4.	81	Defense Purchases and Regional Growth		■				
5.	82	California: Aerospace Industry Has Meant a Second Goldrush		■	■		■	
6.	82	Campus Planning						■
7.	82	Huntsville: Alabama Cotton Town Takes Off Into the Space Age	■				■	
8.	83	Labor Force Projections for 1970 - 1980			■			
9.	83	Science and State Government					■	
10.	84	Is Product Development Conducted More Efficiently in Small Companies		■				
11.	84	New Centers of Excellence		■		■		
12.	85	The Not-for-Profit Research Institute				■	■	
13.	85	$24 Billion for Research		■				
14.	86	The Seduction of Science					■	
15.	87	The Sources of Economic Growth	■					
16.	87	Brains In the Old Manufacturing Belt			■			
17.	87	Seeding Science-Based Industry		■		■		
18.	88	Why New England Grows			■	■		
19.	88	Something Ventured					■	
20.	88	The Role of Public Vocational Education				■	■	
21.	89	A Route 128 for Britain		■		■		
22.	89	Diffusion of Technology Through Universities, Research Institutes and Govt.		■			■	
23.	90	A Research Park Does Not Live by Research Alone				■	■	
24.	90	The University in Economic and Industrial Development		■		■		
25.	91	Universities and Industries in the Space Age		■		■		
26.	91	Some Aspects of Effects of Regional Distribution of Scientific Talent	■		■			
27.	92	The Economic Impact of Defense R&D Expenditures	■		■			
28.	93	The Sources of Invention	■	■				
29.	93	Educational Attainment of Workers			■			
30.	94	The Economic Impact of Route 128	■					
31.	94	Role of the Non-Profit Research Institute				■	■	
32.	95	Adjustments to Reduced National Defense Expenditures	■					
33.	96	Role of a Research Institute				■		
34.	96	Interstate Cooperation and Coordination in Higher Education					■	
35.	97	Assessing Technology Transfer					■	
36.	97	Academic Spinoffs		■		■	■	
37.	98	Technical Change and the Management of Research and Development	■	■				
38.	99	The Speed of Response of Firms to New Techniques	■	■				
39.	100	Proceedings of the Maryland Science-Industry Conference, May 24, 1961					■	
40.	100	Capital Formation and Technological Change in the United States	■	■				
41.	100	Scientific Research in Missouri	■			■		
42.	101	Technology and the American Economy	■		■			
43.	102	Community Readjustment to Reduced Defense Spending	■					
44.	102	American Science Manpower, 1962			■			
45.	102	Basic Research, Applied Research and Development in Industry, 1964		■				
46.	103	Current Projects on Economic and Social Implications of S&T						■
47.	103	Federal Funds for Research, Development, and Other Scientific Activity		■				
48.	104	Technology, Economic Growth and Public Policy	■					
49.	105	Corporate Investment In and Return from Major R&D Projects	■	■				
50.	106	Contracting for Atoms		■				

No.	Page	Title	Impact of S&T	R&D Patterns	Manpower	Location Factors	Action Programs	Other
51.	107	Urban Employment Multipliers and Their Application	■					
52.	107	Meeting Manpower Needs in Science and Technology			■			
53.	108	Taking up Defense R&D Slack With Great Society Programs		■				
54.	108	Research-Based Enterprises				■	■	
55.	109	Research In Mississippi Land					■	
56.	109	Economic and Industry Effects From Research	■			■		
57.	110	Technology Transfer -- Process and Policy					■	
58.	110	Route 128 Study	■			■		
59.	111	Invention and Economic Growth	■	■				
60.	111	The New Regionalism					■	
61.	112	Universities as Research Park Developers				■	■	
62.	113	An Exploratory Study of the Structure & Dynamics of the R&D Industry	■	■		■	■	
63.	114	The Structure and Dynamics of the Defense R&D Industry	■	■		■		
64.	115	The Development of a Potential Defense R&D Complex	■	■		■		
65.	115	The Role of Scientific Research In Stimulating Economic Progress	■	■				
66.	116	Small Colleges Bid for Military R&D Funds		■				
67.	116	Small Business and Innovation		■				
68.	116	Gearing Military R&D to Economic Growth	■					
69.	117	Technical Change and the Aggregate Production Function	■					
70.	117	Manpower Needs in 1975			■			
71.	118	Stanford, Boom in Electronics in the San Francisco Bay Area	■			■		
72.	119	Education In the Upper Midwest Economies			■	■	■	
73.	119	Should a Research Institute be Established in Connecticut?				■	■	
74.	119	The Newly Emerging Community of Technical Scholars		■		■		
75.	120	The Government's Role in University Research				■	■	
76.	121	Defense Industry Diversification	■					
77.	121	Conflicts Between Federal Research Programs & Higher Education						■
78.	122	Convertibility of Space & Defense Resources to Civilian Needs			■			
79.	122	Government, Science and Public Policy		■				
80.	123	Report on the Geographic Distribution of Federal R&D Funds		■				
81.	123	Federal Research and Development Programs		■				
82.	124	Impact of Defense Spending on Labor-Surplus Areas	■		■			
83.	124	The Role and Effect of Technology in the Nation's Economy	■					
84.	125	The Impact of Federal R&D Policies Upon S&T Manpower			■			
85.	125	Scientific Manpower Utilization			■			
86.	126	First Annual Report: Fiscal Year 1966					■	
87.	126	Technology Transfer and Innovation: A Guide to the Literature					■	
88.	126	Technological Innovation: Its Environment and Management	■	■		■		
89.	127	Technological Trends in Major American Industries	■		■			
90.	127	Technician Manpower: Requirements, Resources, and Training Needs			■	■		
91.	128	Some Regional Impacts of Expansion in Domestic Govt. Programs	■	■				
92.	128	Shifting the Composition of Government Spending	■	■				
93.	129	Measurements of Economic Impact of Defense and Space Programs	■					
94.	129	What the Space Race Will Do to You	■					
95.	130	Where Does the Money Come From				■	■	

1. Allison, David, "The University and Regional Prosperity," International Science and Technology, April 1965, p. 22 - 31. (D, E)

The main thrust of Allison's article is the growing recognition of the importance of the academic and research "center of excellence" as a key to future regional economic development. He refers to the efforts of some regions to establish research institutes as an answer, pointing out that the newer research institutes have been less successful than those established earlier because they shaped their activities in the same form as the original institutes and did not take into account significant changes which have occurred over time. The research park was another device designed to develop regional research activity, but this device too has generally proven unsuccessful.

A third approach is to increase the output of Ph.D's. Recognizing that Ph.D.'s are highly mobile and citing numerous examples of the "brain drain," Allison goes on to stress the importance of the strong university in generating spinoffs. He qualifies this, however, by saying that these schools must have a strong engineering and science capability plus policies which encourage faculty participation in company activity -- policies which foster entreprenuership. He goes on then to discuss the developments taking place in Dallas -- specifically, the establishment of the Graduate Center of the Southwest.

In referring to strategies for development, Allison, recogniznizing the various factors which influence development of scientific activity, states that "if you are building from scratch, you don't start with an opera company, you start with top people." Thus, he advocates investing ~~funds in individ~~uals, not institutions. He also stresses the need to relate these activities to the needs of the rest of the community. A center of excellence in isolation will have limited impact.

Finally, if new centers of excellence are to be created, the commitments to education and research must be continuous and big. "Not $200 per citizen per year...but double that. And not for a decade or so, but forever."

2. Baerwald, Mark, "Boulder Space Age Boom," The Sunday Empire (Denver), November 13, 1966, p. 9. (A, D)

This article illustrates, by examples of specific industries, the growth of science-based industry in the Boulder area and some of the factors contributing to that growth. The contributing factors most often mentioned were:

* The University of Colorado
* The Bureau of Standards (Environmental Science Services Administration facility)
* Location (mountains, proximity to Denver)
* A favorable labor supply
* Availability of support services

Development has occurred with virtually no overt development effort on the part of the community. Although often cited as an important factor, many of the firms have very little contact with the University. Such factors as climate, scenery, recreation attractions, and other intangibles seem to have had a significant effect on the success of Boulder in attracting science-based industry.

3. Berkner, L. V., "Whither Graduate Education," Paper presented before the Houston Meeting of the American Physical Society, March 2, 1963. (C, D)

Political leaders have turned to science and to the new technological innovations for sources of new industry, new opportunities for employment, and new products and services. The motivation toward expansion of fundamental knowledge has suddently acquired an economic motivation in addition to the traditional social and intellectual motivations. But to capture the innovation to be derived from today's science, we must have men in sufficient numbers who are trained to command the boundaries of scientific knowledge. Consequently the knowledge of the Ph.D.-trained scientists and engineers is the core of the new science-derived industry. The author stresses the growing need for Ph.D's and the challenge this presents to those universities which now fall behind the top 20 leaders. He also points up the growing trend to produce or acquire Ph.D.'s as a means of regional development, citing that for each Ph.D. we can employ 5 - 10 engineers, at the bachelor level, and for each engineer we can use 10 - 15 skilled workers.

4. Bolton, Roger, <u>Defense Purchases and Regional Growth</u>, The Brookings Institution, Washington, D. C., 1966. (A)

In this book the author presents a model of regional growth and provides estimates of the contribution of defense income to this growth in the period from 1952 to 1962. These estimates show the differential impact of the nation's defense program by states and regions. The author notes that neither a high degree of dependence upon defense

income nor a very rapid growth in defense income will alone contribute significantly to the general growth of a region. However, he then goes on to show that there is, in fact, a definite relationship between regional growth and the amount of defense spending.

5. "California: Aerospace Industry Has Meant a Second Goldrush; Climate and Education Get Credit," Science, Volume 143, No. 3611, March 13, 1964, p. 1151 - 1153. (A, B, D)

People who have watched the aircraft industry in California develop and evolve into the aerospace industry tend to explain the rise of the industry in terms of a simple formula -- Cal Tech plus climate. California Institute of Technology at Pasadena, as a matter of fact, appears to have been a kind of service academy for the aircraft industry. In its undergraduate curriculum Cal Tech appears to have anticipated the postwar trend in engineering and science education with more emphasis on fundamentals of theory and less on applications. In recent years the aerospace industries cultivated close relations with the science side of the Cal Tech faculty as well as with the engineers who, in an earlier period, were more ardently courted. The reason is an obvious one -- that in missile and space projects basic research and applications have become two sides of the same coin. University scientists and industry need each other's resources.

6. "Campus Planning," Urban Land, Vol. 25, No. 11, December 1966, pp. 3 - 10. (F)

This issue of Urban Land includes three papers on campus planning -- "The Urban Campus" by John O. Merrill, Jr.; "The Suburban Campus" by Robert E. Alexander, and "The Existing Campus: Urban and Suburban" by Philip C. Williams. The authors, all physical planners, discuss various elements of campus planning ranging from the potential benefits of the university to the community to such problems as space allocation and supporting facilities.

7. Carter, Luther J., "Huntsville: Alabama Cotton Town Takes Off into The Space Age," Science, Vol. 155, No. 3767, March 10, 1967. (A, E)

The article describes the demographic, economic, and social impact of the Marshall Space Flight Center and its antecedents on Huntsville. Also described are the community's actions to capitalize on its good fortune. In 1950, the year when Dr. von Braun and his associates were first brought to Huntsville, the city's population was

16,400. Today, the population is over 143,000. The combined Army-NASA-contractor workforce is about 40,000 with an annual payroll exceeding $300 million. The city has undertaken a number of steps to create the conditions necessary for the growth of a well-diversified economy. A Huntsville Industrial Expansion Committee was formed. Among other things it coordinated the establishment of a 3,000 acre Research Park adjacent to the Huntsville campus of the University of Alabama. The park has a score of aerospace tenants and the prospect of a TV manufacturer relocating from Chicago to tap the labor market. The legislature appropriated $3 million to build a Research Institute in 1961. The school system has received a $2.7 million grant from the Ford Foundation. The city has an arts council and a Civic Symphony and Chamber Music Guild. A new convention and cultural center is planned.

8. Casper, Sophia, and Denis F. Johnston, "Labor Force Projections for 1970 - 1980," Monthly Labor Review, Vol. 88, No. 2, p. 129, February 1965. (C)

This is a report on the latest national projections by the Bureau of Labor Statistics. Included are sections on the implications of the projected growth and its impact on employment. By 1970 the labor force is expected to rise to approximately 87 million, up about 300,000 from the 1962 published figure due to population growth and to more women entering the work force. The younger workers (under 25) will comprise 24 percent of the labor force compared with 21 percent in 1964. The 1980 labor force is projected at 24.4 million with population increase accounting for about 87 percent of this. The rest is a result of the continued rise of women entering the labor force. The implications of this increase include the facts that the number of part-time workers will increase substantially because of the number of younger workers and women entering the labor force; many will be unexperienced and seekings jobs at entry levels of occupations; and the competition for jobs will increase substantially.

9. Cleaveland, Frederick N., Science and State Government, University of North Carolina Press, Chapel Hill, 1959. (E)

This book explores the role of state governments in the scientific effort of the nation. Separate case studies of the research activities of six state governments -- California, Connecticut, New Mexico, New York, North Carolina, and Wisconsin -- are compared and summarized to give a general view of scientific research as an activity of state government. Research expenditure patterns among four major

areas of governmental activity -- agriculture, resources and public works, health and welfare, and higher education -- are analyzed, and the state programs in each of these areas are outlined in considerable detail. Dr. Cleaveland's findings are summarized briefly as follows:

* Expenditures for scientific activities (in 1954) ranged from 1.25 to 2 percent of total state expenditures for general government purposes.

* Most of these funds were appropriated by the state legislatures with the remainder coming from the Federal Government.

* The distribution of expenditures among areas of activity varied from state to state although agriculture and higher education generally ranked high.

* There is little awareness among state policymakers of a state-wide scientific effort.

* Scientific activity has not gained recognition as a separate function of state government.

* Research has received little emphasis as an aid to policy making.

10. Cooper, Arnold C., "Is Product Development Conducted More Efficiently in Small Companies?," <u>Harvard Business Review</u>, Vol. 42, No. 3, May - June 1964, pp. 75 - 83. (B)

This paper has as its focus the question of whether organizational size has any effect on the cost of developing products. The author concludes, on the basis of interviews and a case study, that for the development of a particular product the small company is usually more efficient. Some of the reasons for his conclusions: (1) the small firm has a larger percentage of men with above average ability; (2) the technical people in the small firm seem to have a higher capability; (3) the technical people in a small firm are much more concerned over costs; and (4) there is difficulty of communication and coordination in the larger firm.

11. Danilov, Victor J., "New Centers of Excellence," <u>Industrial Research</u>, April, 1965, pp. 36 - 45. (D, D)

In 1960 the President's science advisory committee estimated that there were 15 - 20 "centers of excellence" in science education

and research in the U. S. Each of these universities excells in science and/or engineering, and they are able to obtain the necessary funds from public and/or private sources to achieve distinction. But, by definition, the university recipients of the various foundation grant programs all had been driving ahead to higher levels of competence when they were selected, and there are many indications that the special program grants have enabled them to raise their sights even further.

Federal support started with the Land Grant Act and has continued through the National Science Foundation programs. One of the basic controversies over support is the pressure for equal geographic distribution of funds over the nation as a whole. Dr. Dean C. Seaborg of the Atomic Energy Commission says, "we must not let our national support of science and technology degenerate to the point where no state, no congressional district is complete without a post office, a reclamation project, and a new science laboratory."

The Ford Foundation special program and the National Science Foundation science development program have forced colleges and universities to take a closer look at their students, faculty, program facilities, and objectives. The result has been an overall increase in the quality of higher education despite mushrooming enrollment, major expansions, and accelerating costs.

12. Danilov, Victor J., "The Not-for-Profit Research Institute," Industrial Research, February 1966, pp. 30 - 39. (D, E)

In this article the author traces the growth of the research institute from the founding of the Mellon Institute in 1913 to the present. He points out that the research institutes have played a role in the progress of the nation by spurring industry, contributing to defense, and furthering knowledge. Their importance to the research scene is indicated by the fact that they have performed $218 billion in R&D since the first was started; they conduct approximately 4,400 different research projects each year; they have staffs of more than 14,900 and employ above 6,900 scientists, engineers, and other professionals.

13. Danilov, Victor J., "$24 Billion for Research," Industrial Research, January 1967, p. 51. (B)

The nation's research and development expenditures will continue to increase in 1967, but two factors stand out: (1) a slowdown

in the growth of federal funds for R&D; (2) an increase in industrial funds. In fact, industrial funds will account for nearly all the increase in the nation's R&D expenditures. Applied research and development will be hardest hit by the slowdown in federal R&D funding. Expenditures for basic research will continue to increase.

The leveling off of government R&D spending can be attributed to four factors: (1) the increased military needs because of the Vietnam war; (2) funding of new great society programs; (3) growing public and political pressure to hold down federal expenditures; (4) a lack of urgency in R&D programs and the feeling that funds could be spent more wisely and produce even greater returns in other areas.

In the industrial picture, two problems do stand out: (1) the relatively small amount of net sales spent on R&D by small companies, those with less than 1,000 employees; and (2) the small amount spent on R&D by civilian industries such as food, textile, wood, paper and stone that do not receive much federal R&D money. Most of the nation's industrial R&D is financed and performed by five industries -- aircraft and missiles, electrical equipment and communications, chemicals and allied products, motor vehicles and other transportation equipment, and machinery.

14. Danilov, Victor J., "The Seduction of Science," Industrial Research, May 1965, p. 38 - 48. (E)

States have been intensifying their efforts to attract R&D and science-based industries to their area. Efforts include expansion of industrial development programs, creation of science foundations and commissions, establishment of industrial extension services, establishment of research institutes and industrial parks, formation of state research and development agencies, financial assistance, tax incentives, and other measures. For example, two-thirds of the fifty states now offer one or more forms of industrial financing assistance. Seventeen states offer tax incentives.

The author suggests that instead of the standard promotional measures, state funds would be better spent in developing one or more distinguished universities in science and engineering, building a reservoir of scientific and technical manpower and services, encouraging the development of suitable sites for science-oriented facilities, and improving the overall business and living climate.

15. Denison, Edward F., The Sources of Economic Growth in the United States and the Alternatives Before Us, Supplementary Paper No. 13, Committee for Economic Development, New York, 1962. (A)

This study is one of the relatively few significant works which attempt to quantify the elements of economic growth. Of particular relevance is the chapter on the advance of knowledge and its application of production. Denison estimates that 20 percent of the growth rate in total national product can be ascribed to increase in knowledge and its application. He stresses that this advance in knowledge includes not only technological knowledge but managerial and organizational advances as well.

In discussing the role of education in economic growth, Denison estimates that, between 1929 and 1957, improved education raised the average quality of labor by 29.6 percent, or an average annual rate of 0.93 percent.

16. Deutermann, Elizabeth P., "Brains in the Old Manufacturing Belt," Mainsprings of Growth, Federal Reserve Bank of Philadelphia, March 1967, pp. 82 - 87. (C)

This article presents a profile of technical talent in five communities of the old manufacturing belt. The five cities are Boston, Philadelphia, Baltimore, Chicago, and St. Louis. The profile highlights where the brains reside, what special talents they possess, and their educational attainment. The study demonstrates the East Coast attraction for research activity. A separate profile is made on engineers. These profiles indicate that more scientists are working in chemistry than in any other major field. For engineers, the highest percentage specializes in electronics or electrical machinery.

17. Deutermann, Elizabeth P., "Seeding Science-Based Industry," New England Business Review, May 1966, pp. 3 - 10. (B, D)

On the basis of a survey of new science-based firms in Boston and Philadelphia, the author explores the conditions which appear to be needed to encourage establishment of fledgling industries. First, of course, there must be a scientist or engineer with an idea who wants to start his own firm. Beyond that, the community must show receptiveness to new ideas by tangible support.

Financing is a key. There must be an understanding financial community attuned to the needs and problems of the new firm. The

presence of a strong university can also be an important factor, although opinions vary on this question. Much depends on the attidue of the university toward the business community. Other factors include availability of low cost space (seldom a problem) and a pleasant physical, cultural, and intellectual environment.

18. Eisenmenger, Robert W., "Why New England Grows," New England Business Review, February 1967, pp. 2 - 6. (C, D)

In this article, based on his recently published book, The Dynamics of Growth in New England's Economy, 1870 - 1964, the author explains that the labor force of the area is one of its main attractions to industry. Three important factors are the lower than average wages of semi-skilled and skilled workers; the character of the labor force (dependability, productivity, and low turnover); and the above average educational and worker training programs. Because of these factors, employers specialize in activities that require labor intensive technology -- which requires large numbers of man-hours devoted to a small volume of raw materials to create a high value product.

19. Elliott, J. Richard, Jr., "Something Ventured," Barron's, March 6, 1967, p. 3. (E)

This article describes the investment philosophy and operations of American Research and Development Corporation -- one of the more successful private corporations providing venture capital to new science-based industry. Primary investment criteria of this company, the forerunner of the small business investment companies, are: (1) "Is there a market? ", and (2) "Are they (the men) brilliant -- abnormally brilliant? ". With numerous examples, the article illustrates the type of activities financed by the company.

20. Estle, Edwin F., "The Role of Public Vocational Education," New England Business Review, January 1967, pp. 2 - 6. (D, E)

This study, based on interviews with 24 firms in 7 industries in the greater Boston area, indicates that industry maintains its own training programs to meet specific needs and does not rely on the vocational system for fully-trained workers. The training in vocational school provides a foundation for specialized on-the-job training.

21. Goodeve, Sir Charles, "A Route 128 for Britain?," New Scientist, February 9, 1967. (B, D)

In this article the author examines the area around MIT and Harvard on Route 128. He points out four ingredients which were present and which have greatly aided the development in this area to the point "that now a location on Route 128 possesses considerable status."

The first aid to development in the area or any area he notes is a first-class university strongly oriented toward applied science and technology. He also is quick to point out the encouragement given to the staff or faculty to spend time on industrial work, either as directors or consultants.

Secondly, he points out the large research "centers" on the university campus. These centers concentrate on research with little or no time devoted to teaching. He notes that most of them draw their funds from the federal government with very little money coming directly from industry. He also points out the fact that it is from these centers and laboratories that the "spin-off" industries come.

The third aid to the development of the area is the ease that firms have in locating along Route 128 and that this is an area of natural amenities. He credits the proximity of Harvard and MIT and other research institutions in the area as being one reason that large firms have located their research labs in the area. These universities and other firms are attractive to scientists and make recruitment easier. The author feels that "it is also stimulating to research scientists and makes their work more productive."

The last ingredient he cites is the large supply of private venture capital available to new firms in the United States.

22. Green, John C., "Diffusion of Technology Through Universities, Research Institutes and Government," Paper presented at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963. (B, E)

The author explains the Civilian Industrial Technology Program of the Commerce Department -- designed to stimulate additional public and private investment in industrial research. The four means proposed to accomplish the purposes of this program are:

1. Supporting the training of personnel at universities for industrial research and development.

2. Stimulating research in industrial institutions.

3. Development of an industry-university extension service.

4. The support of better technical information services to meet industry's specific needs for knowledge about technological activities and developments.

23. Griefen, R. John, "A Research Park Does Not Live by Research Alone," Urban Land, Vol. 24, No. 3, March 1965, pp. 3 - 7. (D, E)

In this article Mr. Griefen examines research parks -- their characteristics and reasons for not being complete successes. The author contends that some research parks fail because they restrict the use to research alone. He argues that there must be mixed uses -- research, offices, and light industry. Another factor is that industrial management often prefers to have its research facilities located away from the activities of other companies. There are several reasons for this:

1. Research facilities are often used as a show place and officials wish to maintain the corporate identity;

2. They often wish R&D facilities to be located near company headquarters or production facilities;

3. They are concerned over the problems of maintaining security.

The author goes on to described Technology Square and the growth and success this research park has experienced.

24. Hobson, Jesse E., "The University in Economic and Industrial Development," Paper presented at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963. (B, D)

In this paper Dr. Hobson states that "the university today is closely tied and related to the economic development of its community and its region, and in this period of rapidly-expanding technology is a key factor in the development and environment of industry and is,

therefore, a critical factor in maintaining and expanding employment." He contends that teaching alone is not sufficient today -- the university must do more. He also states that the research institute must become more closely related to the graduate university.

25. Hollomon, J. Herbert, "Universities and Industries in the Space Age," presented at University Industry Liaison Conference sponsored by the University of Colorado, Colorado State University, and the University of Denver, November 4 and 5, 1963. (B, D)

Universities in his view should train people not only in research but in the art and science of applying knowledge to human needs. In many cases this means just applying existing knowledge rather than the development of new. He also contends that we need a new means, based on the university, of disseminating technical information to industry generally. There is a proper role for federal and state support for the technical activities basic to industry generally which will not interfere with the market decisions that are properly the role of industry itself.

According to the author:

1. Much of the technical knowledge that is now produced is not related to the basic economic and social needs of our society;

2. Too often our brightest people are trained in specialties that service huge national programs;

3. The mounting mass of technical and other information is not being effectively disseminated or put to use by those who would profit by it.

26. Horowitz, Ira, "Some Aspects of Effects of the Regional Distribution of Scientific Talent on Regional Economic Activity," Management Science, Vol. 13, No. 3, November 1966, pp. 217 - 231. (A, C)

This article reviews a research project which set out to explore whether regional R&D activity will have a stimulating effect on a region's economic activity. In order to pursue this question a multi-equation econometric model was derived to determine the extent to which the spatial distribution of scientific talent is in turn reflected in regional economic activity. It was concluded that such economic variables as investment in plant and equipment, employment

and earnings are positively related to the distribution of scientific talent, although these relationships are relatively inelastic. It was concluded that concern for the scientific sophistication of a region's population and the economic implications of this sophistication is by no means misplaced.

27. Howell, Richard P., William N. Breswick, and Ernest D. Wenrick, The Economic Impact of Defense R&D Expenditures: In Terms of Value Added and Employment Generated, Stanford Research Institute, February 1966 (Draft Copy). (A, C)

This study is an attempt to develop information and techniques for evaluating the economic impact of defense R&D expenditures. Significant conclusions include the following:

1. On the average, prime contractors spend three-fourths of defense R&D funds within their own establishments.

2. Small businesses spend less than half of their contract funds with other firms.

3. Nonprofit organizations spend but one-seventh of the contract funds outside.

4. The contractor located in a large R&D complex tends to sub-contract more than does a contractor located in a smaller complex.

5. Contrary to popular belief, the portion of funds used for outside procurement does not vary significantly as work progresses from start to finish.

6. The amount of the defense R&D subcontracting and purchasing that is spent locally is a function of the size of the local complex, and the size and distance of alternative complexes.

7. Work on large contracts will be subcontracted to a greater extent than will work on smaller contracts.

8. On the average, an expenditure of $14,000 on defense R&D will generate one full-time job for one year.

28. Jewkes, John, David Sawers, and Richard Stillerman, The Sources of Invention, MacMillan and Company Ltd., London, 1958. (A, B)

This book, still one of the best treatments of the subject of invention, is based on case studies of about 50 specific inventions ranging from automatic transmissions to zip fasteners. The conclusions drawn from these case studies may be summarized as follows:

1. The history of invention shows no sharp break in continuity -- i.e., patterns are essentially the same today as they were 100 years ago.

2. There is little evidence to support the view that inventions can be predicted. Most specific inventions were not foreseen -- they had an element of the accidental in them.

3. There is some doubt that the speed of development of inventions is more rapid now than in previous times.

4. There may be some dangers in the trend toward the institutionalization of research -- the shift in emphasis from individuals to institutions.

5. Because it is virtually impossible to determine whether large or small organizations are more effective, we should strive to maintain a balance between different sources of inventions.

6. Efforts should be made to assist the individual inventor.

The last half of the book is devoted to tracing the development of each of the 50 inventions.

29. Johnston, Denis F., "Educational Attainment of Workers, March 1964," Monthly Labor Review, Vol. 88, No. 5, May 1965, p. 517. (C)

This article points up both the growing supply of better educated entrants into the labor force and the rising demand for workers with high levels of technical skill and training. Major points covered in the article include trends in relationships between education and occupation, education and income, and education and labor force demand. The trends in educational attainment indicate that impressive gains have been made between 1940 and 1964. The proportion of workers age 18 to 64 who have 4 years of high school

has risen from 32 to 57 percent while those with 4 years of college or more has increased from below 6 percent to over 11 percent. There is a leveling off of the upgrading of education among women with the result that the educational attainment of men has been approaching that of women. Between 1940 and 1964 the proportion of workers with at least 4 years of high school nearly doubled among men but only increased by about 40 percent among women.

30. Johnson, Roger, The Economic Impact of Route 128, Associated Industries of Massachusetts, November 1960. (A)

The purpose of this study of firms located along Route 128 was to provide information to manufacturers on the economic potential inherent in such a new road. Firms surveyed were limited to those actually located on Route 128 or visible from the highway. The study revealed that:

1. Of the 169 establishments built along the highway, one-third are engaged in manufacturing, but these account for two-thirds of all employment.

2. Three out of four of the new establishments were previously located in Massachusetts.

3. Only 12 of the establishments were new companies, although 31 were new divisions of existing companies.

4. Approximately 60 percent of the 12,000 new jobs created through locations on Route 128 have been produced by companies that were formally located in the greater Boston area.

5. Urban centers, particularly Boston, Cambridge, Quincy and Sommerville, lost almost 10,000 jobs through relocation of firms from those cities to Route 128.

6. Of the 24,000 persons now employed along Route 128, two-thirds are in electronics and research and development.

31. Kimball, Charles N., "Role of the Non-Profit Research Institute and Its Relation to Industry and Government," Paper presented at the U. S. Department of Commerce State Science and Technology Conference, Washington, D. C., February 3 - 4, 1964. (D, E)

Research institutes provide the applied science link between those who know modern technology and those who need to know.

Institutes are concerned with both generating and communicating knowledge to government and industry across the entire spectrum of physical and social sciences. The author traces the development of research institutes and gives examples of the type of work they have done for both industry and government. He points out that the role of the research institute is changing, that it increasingly is serving as a point of focus to help industry keep informed of technological developments. By hiring competent people, whom they use as scientific intelligence agents, the research institutes can determine not only what is new, but how best to use the information that is generated.

32. Kirschner Associates, <u>Adjustments to Reduced National Defense Expenditures in New Mexico</u>, December 1965. (A)

This study, sponsored by the U. S. Arms Control and Disarmament Agency, had as its specific purposes: (1) to determine what problems related to economic redevelopment will be created in New Mexico by assumed changes in the level and/or composition of national defense spending; (2) to evaluate the effectiveness of existing policies, programs and administrative machinery for dealing with economic redevelopment problems in the state caused by assumed changes in defense spendings; and, (3) to recommend, as required, new policies, programs, and administrative machinery relevant to the governmental and private spheres for adjusting to assumed changes in defense spending in the state.

The study found among other things that a change in defense spending would result in larger than normal problems -- reduced employ-employment and income -- because of two things: (1) the important role of defense industry in the economy and (2) the traditionally agricultural and mining economy of New Mexico. The findings showed that even though there would be statewide effects if expenditures were reduced the local effects would reach depression levels with some communities suffering as much as a 30 percent decrease in employment. Their requirements for adjustment included developing alternative basic export activity, a system of information and analysis to anticipate and evaluate the impact of changes in defense spending, mechanisms for cooperative government action at all levels, and methods devised to facilitate rapid action in adjustment to anticipated changes.

33. Krause, Ralph A., "Role of a Research Institute," Stanford Research Institute, prepared for the United Nations Conference on the application of science and technology for the benefit of the less developed areas, held in Geneva, Switzerland, February 4 - 20, 1963. (D)

In his summary the author says that a research institute can be of great usefulness to a country because it can provide a trained manpower pool for a development program, translate world technology to adapt to a country's environment, provide mechanisms for import of scientific and technical consultants, arrange for scientific and technical education and training abroad, provide supplemental activity and income to university staff, lay groundwork for development of scientific and technical self-sufficiency in the future, achieve prestige of the scientific and technical community to become welcome as participants in world scientific advance, develop scientific and technical educational motivation of students and assistance in achieving a scientific or technical career, and develop and administer standards and testing procedures and help in the administration of quality control techniques. Regarding the institute itself, he says that the important factors regarding success and usefulness are: the acumen and edication of the directing and organizing and promoting the institute, the availability of the scientific and technical talents, the breadth of interest by industry and government, the financial and contract support, and the liaison, the foreign personnel, information, and facilities. While this was written for an institute in a less developed country, some of the items mentioned under both usefulness and factors regarding success are applicable to regions of the United States.

34. Kroepsch, Robert H. and M. Stephen Kaplan, "Interstate Cooperation and Coordination in Higher Education," Emerging Patterns in American Higher Education, American Council on Education, 1965. (E)

This article examines three interstate compact organizations -- the Western Interstate Commission for Higher Education, the Southern Regional Education Board, and the New England Board of Higher Education. It describes their origin and growth, legal mandate, organization, and financing. It also gives examples of their programs. Their programs, which are similar in many respects, are discussed under the following headings: Interstate Contracts, Regional Common Market Programs, Needs and Resources Studies, Higher Education Planning and Research, In-Service Training and Continuation Education Programs, Curriculum Development Projects, Promotion of Institutional Cooperation, and Public Information.

35. Lesher, Richard L., and George J. Howick, Assessing Technology Transfer, NASA SP-5067, Scientific and Technical Information Division, Office of Technology Utilization, National Aeronautics and Space Administration, Washington, D. C., 1966. (E)

This publication is an abridged version of the report prepared for the National Commission on Technology, Automation, and Economic Progress. It provides a good summary of the subject of technology transfer -- the needs, the processes, existing and proposed programs and mechanisms. Included is a description of technical information programs of selected federal agencies. The report also includes a bibliography focusing on, but not limited exclusively to, technology transfer. The authors conclude:

1. Traditional means of transferring technology are no longer wholly adequate due to the volume of new technology, the pace of its discovery, the complexity of the economy, and the gap between the military/space/nuclear sector and the main body of the economy.

2. A communications gap exists between the principal generators of new technology and large bodies of potential users.

3. Technology transfer is one area where it is difficult to move programs foreward because of the responsibility being shared by the public and private sectors.

36. Mahar, James F. and Dean C. Coddington "Academic Spinoffs," Industrial Research, April 1965, pp. 62 - 71. (B, D, E)

This article attempts to identify conditions which lead to the formation of spinoff firms by examining the process in specific cases. Spinoff firms occur when people are able to identify and take advantage of opportunities. Technical knowledge combined with market knowledge is the main impetus.

The problems faced by the small technically oriented companies generally seen to fall into the following categories: finance, managerial ability, need for proprietary products, influence of external forces, and community attitudes.

According to the authors, the university spinoff firm increases the social and economic value of research by helping to apply new technology, by helping to seed development of further scientific activity, by utilizing untapped managerial talents.

Although university policy varies, the university which encourages this type of entrepreneurial activity has much to gain. This type of activity helps to stimulate graduate students, promotes and strengthens interaction between the university and industry, and encourages and teaches entrepreneurship. This does not mean, however, that there are no dangers involved. Problems often cited are that professors neglect academic duties, that the research and extra cirricular activities of professors seem to have a harmful effect on undergraduate teaching, and that basic research is neglected while professors carry out applied research and spend time establishing their own firms. University policy will be one of the key factors determining the amount of spinoff activity which occurs in the area.

37. Mansfield, Edwin, "Technical Change and the Management of Research and Development," Technical Change and Economic Growth, Michigan Business Paper No. 41, Michigan University Graduate School of Business Administration, Ann Arbor, 1965, pp. 19 - 31. (A, B)

The author made three observations regarding R&D and the significant inventions a firm produced. These were based on studies of the coal, petroleum and steel industries.

1. There seems to be a close relationship over the long run between the amount a firm spends on R&D and the total number of important inventions it produces.

2. Except for chemicals, there was no indication of any marked advantage of very large-scale research activities over medium-sized and large ones.

3. The evidence suggested that the productivity of an R&D effort of a given scale is lower in the largest firms than in the medium-sized and large ones.

Regarding the size of the innovator, the studies showed that while it is alledged that the largest firms do more than their share of the innovating, this is not always true.

Several conclusions were also reached regarding the diffusion of innovation.

1. There seems to be definite "bandwagon" effect.

2. The rate of diffusion tends to be higher for more profitable investment and those requiring relatively small investment.

3. There is a tendency for the rate of diffusion to be higher when very durable equipment is not replaced, when the industry's output is growing rapidly or when the innovation's introduction into industry is relatively recent.

4. The speed with which a particular firm starts using a new technique is directly related to a firm's size and to the profitability of its investment in the technique.

5. Only a weak tendency exists for the same firm to be consistently the earliest to introduce different techniques or innovations.

The studies also suggested that, over the short run, firms maintaining a fairly constant ratio between R&D and sales, but over the long run the R&D budget is influenced by a kind of "Bandwagon" effect. In pointing out a possible gap the author suggests that research be carried out on new and improved techniques for measuring the economic returns from new and more widely diffused knowledge.

38. Mansfield, Edwin, "The Speed of Response of Firms to New Techniques," The Quarterly Journal of Economics, Vol. LXXVII, No. 2, May 1963, pp. 290 - 311. (A, B)

This paper is one of several by Mansfield reporting on his studies of research, technical change, and economic growth. Findings reported in this paper are summarized as follows:

1. There is an inverse relationship between size of firm and the length of time a firm waits before using the new technique;

2. There is an inverse relationship between the profitability of a firm's investment in an innovation and the length of time a firm waits before using the new technique;

3. The technical leadership does not tend to be highly concentrated among firms within an industry; and

4. There appears to be no significant relationship between a firm's financial health and the length of time it waits before introducing a new technique.

39. Maryland Department of Economic Development, *Proceedings of the Maryland Science-Industry Conference, May 24, 1961*, Annapolis, Maryland, January 1962. (E)

Officials of the State of Maryland recognize that industrial growth and the resulting increases in employment and prosperity occur most readily in those industries which have high degree of research and development activity. In turn, R&D activities prosper most in areas with a strong scientific, technological, and cultural environment. The purpose of this conference was to determine the potential and the requirements of the area for science and science-based industry as well as to establish the steps which must be taken to further the development of this important aspect of the economy. Many of the questions raised regarding Maryland are the same as those being raised in other regions -- what makes a science complex, what does Maryland now offer science industries, what does Maryland need to become a major science complex, what should Maryland do now to foster the growth of science and science-based industries in the State?

40. Massell, Benton F., "Capital Formation and Technological Change in the United States Manufacturing," *The Review of Economics and Statistics*, Vol. XLII, No. 2, Harvard University Press, May 1960, pp. 182 - 188. (A, B)

This paper reports on an effort to apportion increases in output per man hour between increases in capital employed per man hour and "technological change." Massell concludes that approximately 90 percent of the increase in output per man hour during the period 1929 - 1955 can be attributed to technological change. The author also points out that the rate of technological advance will be influenced by the rate of capital formation. Thus, technological change is likely to occur most rapidly in an economy which is expanding its capital stock.

41. Murry, Donald A., *Scientific Research in Missouri*, Research Center, School of Business and Public Administration, University of Missouri, February 1965. (A, B, D)

The purpose of this study was to ascertain the consequences and prerequisites of R&D in the state economy. Aside from economic benefits, the author notes that the current interest in R&D from a regional viewpoint is stimulated by the fact that it is a "clean industry" and that local prestige is involved. The study explores

two types of economic benefits: (1) from the performance of research within a region and (2) from the use of research findings by local industry in technological change. The study finds that there are economies of agglomeration which tend to result in research clusters and that existing research attracts additional research to these clusters. The attractiveness of federal research contracts to a region is enhanced by the follow-on relationship between development and production. It is noted that the economic impact upon local resources of production of a follow-on item may surpass by far the economic impact inherent in R&D activity. The paucity of information relevant to regional scientific research is noted at several points throughout the study. The study culminates in a series of correlations attempting to account for differences in scientific research in Missouri, California, Texas, Illinois, Kansas, and Arkansas. Although the correlations shed some light on causes, the author notes that they leave much unexplained.

42. National Commission on Technology, Automation, and Economic Progress, Technology and the American Economy, Report of the Commission, February 1966. (A, C)

This report, along with its six appendix volumes, represents a major effort to explore the subject of technology and its impact on the economy. The report deals with such subjects as the effect of technological change on the outlook for employment in 1975, programs to aid the poor, the use of computers in educational institutions, and the relationship of new technology and urban planning. The appendix volumes include:

I. The Outlook for Technological Change and Employment
II. The Employment Impact of Technological Change
III. Adjusting to Change
IV. Educational Implications of Technological Change
V. Applying Technology to Unmet Needs
VI. Statements Relating to the Impact of Technological Changes

The first five volumes contain a series of studies by experts on the various subjects. The sixth volume consists of a group of statements by various interested organizations and individuals presenting their views on the impact of technological change. Selected papers are included as separate entries in this bibliography.

43. National Planning Association, Community Readjustment to Reduced Defense Spending, Washington, D. C., December 1965. (A)

This study, sponsored by the U. S. Arms Control and Disarmament Agency, is concerned with the policies which may be needed to facilitate adjustment to arms reductions and mitigate the hardships that will persist until the adjustment can be completed. Case studies of Seattle-Tacoma, Baltimore, and New London-Groton-Norwich suggest that new policies should be developed to cope with arms reductions. These policies should incorporate varying degrees of federal leadership, depending on the size of the arms reduction and the area. The Federal government should encourage local and private participation, and its policies should be nondiscriminating and consistent with other national objectives.

44. National Science Foundation, American Science Manpower, 1962, U. S. Government Printing Office, June 1964. (C)

This report analyzes in detail the education, employment, scientific specialization, and other characteristics of the 215,000 U. S. scientists as of 1962. The educational characteristics are broken by highest degree and subgrouped by fields, age, employment status, types of employers, work activities, and years of experience. Employment characteristics are broken by type of employer, field, age, work activity, and years of experience. Also covered are salaries, geographic location, foreign language, scientific and technical subfields, and programs sponsored by the U. S. Government.

45. National Science Foundation, Basic Research, Applied Research and Development in Industry, 1964, June 1966. (B)

To record the growth, volume and other characteristics of R&D activities, the National Science Foundation has carried out a series of annual surveys in various sectors of the Nation's economy. This report concentrates on industrial R&D funds. The data are presented by size of company and R&D program, by geographic distribution, and by major types of expense. The relationship between R&D funds and employment and net sales are also presented. Data on employment of R&D scientists and engineers (as of January 1, 1965) are also shown in this report.

46. National Science Foundation, Current Projects on Economic and Social Implications of Science and Technology, 1965. (F)

This report, issued yearly, provides a bibliography of current university-based research in the subject areas. Projects are cataloged under 14 subject categories which are:

1. Administration, Organization, and Management
2. Agriculture and Rural Sociology
3. Automation and Impacts on Labor
4. Decision Making
5. Economic Development
6. General Economic Analysis
7. History and Philosophy of Science and Technology
8. Impacts on Selected Industries
9. Innovation, Including of Specific Inventions and New Processes
10. International and Foreign Studies
11. Patents and Trademarks
12. Public Policy, Government, and National Defense.
13. Scientific and Engineering Manpower: Performance, Education, and Creativity
14. Sociology and Psychology

47. National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activity, Fiscal Years 1965, 1966, and 1967, Volume XV, U. S. Government Printing Office, 1966. (B)

The purpose of this report is to provide a body of systematic statistical data on the size and scope of federal spending for scientific activities, to indicate the methods by which these funds

are spent, and to show important trends in major spending areas. The total dollar amounts are broken down into three sections: Federal Funds for Research, Development, and R&D Plant; Federal Funds for Scientific and Technical Information; and Federal Funds for Collection of General-Purpose Scientific Data. The latter two sections are further subdivided into Characteristics and Activities. The first section is broken into eight subsections:

1. Levels and Trends
2. Basic Research
3. Applied Research
4. Development
5. Performers
6. Agencies
7. R&D Plant
8. Foreign Performers

From this information it can be determined how much is being spent, where, by whom, and for what purposes.

48. Nelson, Richard, Merton J. Peck, and Edward D. Kalacheck, Technology, Economic Growth and Public Policy, The Brookings Institution, Washington, D. C. 1967. (A)

This book has as its focus the view that technological knowledge is the key determinant of the rate of production and general economic progress. The book synthesizes recent data on the relation of research and innovation to economic growth. It analyzes the way in which technological advances occur, the impact of new technology on the economy, and the changes in governmental policy needed to stimulate these technical advances and make them productive. Because the authors feel that existing programs do not adequately encourage private incentive and capabilities, they have presented five proposals to deal with these problems:

1. A federally supported National Institute of Technology to sponsor research and experimental work in the middle ground between academic work and product development.

2. A limited number of government supported R&D programs on large, technically advanced systems.

3. A limited number of continuing government R&D programs relevant to specific industries.

4. The use of government procurement to stimulate early experimental use.

5. An industrial extension service to promote diffusion of new technology.

The industrial extension service activity is being initiated now under the State Technical Services Act but was included under proposals since it is such a new program and is untested.

49. Olson, R. W., "Corporate Investment in and Return from Major R&D Projects," Paper presented at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963. (A, B)

In this article the author defines R&D for industry as covering a good deal more than mere scientific research. In fact he says, "Scientific research in the university sense is merely the starting point." He then goes on to describe the research and development which has taken place at Texas Instruments. The characteristics of the research programs are: (1) they must be a part of management strategy, management must know what is going on and what the possibilities are, (2) the scope of objectives for the project should be clearly defined, (3) the best people in the company should work on these projects and know that they are of importance to the company. The author believes that for major returns on R&D five things are needed: (1) more participation of management in settling R&D objectives, (2) better comprehension of the possibilities in the limitations of research, (3) fewer, more appropriate projects, (4) better assignment of rather than more people, and (5) the guts to stop superfluous projects, that is those which are limited in scope, habitual or inappropriate ones in which the sponsoring organization wouldn't act even if successful.

50. Orlans, Harold, Contracting for Atoms, The Brookings Institution, Washington, D. C., 1967. (B)

This book is concerned with the public policy issues posed by the Atomic Energy Commission's contracting with private organizations for R&D and for the management of government-owned nuclear plants and laboratories. It is based on over 100 interviews with officials at AEC headquarters and regional offices, contractor personnel, and others knowledgeable about nuclear affairs; public documents; and a large volume of private communications. The author's conclusions and recommendations included the following points:

* The policy of relying upon contracting for R&D and managerial services has worked well to date and there are few grounds for converting any facility to an intramural basis. However, this policy should be re-examined periodically.

* The policy of reviewing rather than routinely renewing contracts was overdue and might be extended to laboratories operated by universities.

* The commissioners need to state more clearly the policies that guide their decisions. It would give the AEC and the contractor staff guidance about the future direction of commission policy.

* Conflicts of interest must be guarded against even more strongly than in the past.

* The management of basic research facilities by groups of academic institutions appears desirable since it promotes equitable access by many scientists, but the laboratory director must retain the authority to make on-the-spot decisions necessary to optimize use of the facilities.

* The growth of cost controls, uniform regulations, and detailed reporting requirements have proceeded to a point that contractors regard as excessive and expensive.

* A fuller and freer competition for R&D funds should be promoted between the national laboratories and private industry.

* Programs regarding civilian reactor contracting need clear technical and economic objectives.

51. Park, Se-Hark, "Urban Employment Multipliers and Their Application to the Aerospace Industry in St. Louis," Washington University, Working Paper, June 1965. (A)

This study attempts to incorporate export employment effects explicitly into the Keynesian investment multiplier framework. The primary purpose of the study is to analyze through multiple regression estimation methods the multiplier effects on local employment in the St. Louis SMSA resulting from monthly variations in investment and in the aerospace and other major export activities. Its importance lies in the attempt to measure these two things. Previous studies had been mainly concerned with export activities. From this he was able to show that the multiplier analysis for the aerospace industry indicated that if a projected annual rate of increase in employment in the aerospace industry prevails at 1,000 the area local employment would show a net gain of about 826 and the total employment gain of 1,826. If this multiplier is applied to a hypothetical case of a 10 percent cutback of employment the area economy would suffer a loss of 3,500 jobs in the aerospace industry and a reduction of another 2,900 jobs in various consumption and services industries in the area.

52. President's Science Advisory Committee, Meeting Manpower Needs in Science and Technology, Report No. 1: Graduate Training and Engineering, Mathematics, and Physical Sciences, The White House, Washington, D. C., December 12, 1962. (C)

Because of impending shortages of scientists and engineers, the committee was asked to assess the relation between the present supply of scientific and technical manpower and the manpower needs. The committee recommended a concerted effort to expand the nation's capabilities in graduate education and training. Specific recommendations include: (1) increase the fraction of high-ranking college graduates who undertake advanced study; (2) improve college courses in science and engineering and make them more widely available; (3) increase the number of qualified technicians and use them more effectively.

53. Pursglove, S. David, "Taking Up Defense R&D Slack with Great Society Programs," DATA, March 1965, p. 45. (B)

As military research funding shrinks for the third consecutive year, more defense R&D firms are turning to other government but nonmilitary programs to take up some of the slack. None of the companies expects to make a good living now or in the immediate future from these new fields. Most expect, however, to accomplish two things: (1) hold together for now their technical and management team, and (2) develop a firm ground floor position in areas that are likely to become major national programs. There is little doubt that the major national problems of the next 15 years will be tackled on a national basis. An example already is the Federal government bringing local and regional pollution problems before the sights of federal guns. Likewise, programs of research and construction grants are so framed as to encourage regional master plans and cooperation. However, some companies and some local governments are not idly waiting the government in Washington. The outstanding instance to date is the California experiment of putting the unique technical and management capabilities of defense R&D contractors to work on major state problems.

54. "Research-Based Enterprises," New England Business Review, Federal Reserve Bank of Boston, July - August 1958. (D, E)

In describing the characteristics of the research-based firm, this article traces the typical pattern of development and identifies some of the problems associated with this type of fledgling company.

In describing the role of these organizations in the New England economy, it is pointed out that "The mere existance of a large number of small research-based firms does not mean that they are playing a more important role in the growth of the region than the large firms. The small firm will be economically important only if it grows and carries out actual production in the area."

The problem of financing research-based enterprises is discussed at length. Sources of financing include individuals, banks, venture capital organizations, and the public. Different phases of company growth require different types of financing (initial, interim, growth). Money is available for investment in the research-based firm, but better channels are needed for bringing investor and entrepreneur together.

55. "Research in Mississippi Land," The Changing Middle South, Fall 1966, pp. 22 - 23. (E)

In this article the plans and programs of the Mississippi Research and Development Center are examined. The research development effort, implemented by the eight divisions of the center, has one fundamental goal -- to bring the state's per capita income up to the U. S. average by the year 2000. Specific objectives include:

1. Identify the economic potentials of each section of the state.

2. Determine and help stimulate ways of expanding and diversifying established business and industry.

3. Identify obstacles and problems which must be resolved.

4. Provide management, engineering, and planning assistance to business and industry, and local, area and state development agencies.

5. Provide needed information services through a data center, library, and a computer center.

6. Identify opportunities for expanding the state's economy through further development of port and waterway potentials.

7. Carry out a manpower research program designed to identify manpower resources and provide the skills required to develop payroll potentials.

8. Train people in economic development techniques so the state will have skilled manpower required to implement local, area and state development programs.

56. Ritterskamp, J. J., Jr., "Economic and Industry Effects from Research," Paper presented at the Engineering Institute, University of Wisconsin, Madison, January 31 - February 1, 1963. (A, D)

In this article the author points out the necessary role of basic research and its relation to the total applied research and development effort. Of particular relevance is his discussion of the factors which should be considered in the selection of the laboratory location. According to Mr. Ritterskamp, from a corporate

point of view, the factors to consider are: (1) the research laboratory should be neither too far from or too near to corporate or division headquarters or production facilities, (2) the research laboratory should be located in a community where a friendly environment and political attitude have been demonstrated to similar laboratories, (3) the laboratory should be accessible by normal methods of transportation, (4) general characteristics to be considered in the actual site selection include its general attractiveness, the opportunity for expansion, the availability of utilities, the total cost of land and construction, and taxes. From the research directors point of view these are the important factors: (1) easy accessibility to universities, the availability of manual and clerical workers, (2) the availability of the outside services upon which a laboratory depends -- maintenance shops, machine shops and chemical supply houses, for example. From the point of view of scientists and engineers the most important factors are (1) adequate primary and secondary schools, (2) cultural and intellectual environment, (3) housing to accomodate several economic levels, (4) recreational and religious facilities, (5) general attractiveness of the area.

57. Rosenbloom, Richard S., Technology Transfer -- Process and Policy, National Planning Association, Special Report 62, July 1965. (E)

In this report the author examines the question of technology transfer -- specifically, civilian use of military technology. He says "the radical change in the nature of military technology may make the attainment of secondary applications far more difficult to achieve now than in the past." He examines the present technology transfer efforts, such as those being made by NASA and the AEC. He concludes by saying that the transfer of technological information from the defense and space field is a complex and poorly understood process. More research and debate is required before definite conclusions can be reached about the possibility of influencing this process in a positive manner.

58. "Route 128 Study," Massachusetts Institute of Technology, December 1958. (A, D)

This study, jointly sponsored by the Massachusetts Department of Public Works and the U. S. Bureau of Public Roads, is primarily concerned with the impact of Route 128 as a new road, rather than the impact of the new technology firms which located along the route. Route 128 is a 55-mile circumferential limited access highway around Boston which was completed in 1951. Investment in new plants

up to 1957 totaled $85 million. By type of industry this investment was distributed as follows: Production - 66 percent, Distribution - 21 percent, R&D - 9 percent, Service - 4 percent. Only about 25 percent of the investment was made by "new" firms, the balance came from firms moving out from the center of Boston. The five most common reasons given for locating on Route 128 were: need land for expansion, accessibility for commercial purposes, attractiveness of site, labor market considerations and accessibility for employees.

59. Schmookler, Jacob, Invention and Economic Growth, Harvard University Press, Cambridge, 1966. (A, B)

In his book, Schmookler explores the relationships between technological advance and economic growth. He concludes that the value of invention, not the cost, is the dominant factor determining the course of inventive activity. By relating patent statistics to value added and investment in plant and equipment, the author shows that inter-industry differences in the number of capital goods inventions tend to be proportional to corresponding differences in capital goods sales in the immediately preceding period. Thus, technological advance occurs in response to changes in market demand instead of the popular view to the contrary -- that technological advance stimulates industrial growth.

Schmookler makes the important point that "the effect of the growth of science is normally felt more from generation to generation than from one issue of a scientific journal to the next." He also tends to downgrade the importance of scientific discovery as a stimulus for further immediate invention.

60. Schon, Donald A., "The New Regionalism," Harvard Business Review, Vol. 44, No. 1, Jan. - Feb. 1966, p. 30. (E)

In this article the author asserts that states and regions are seeking economic growth in the wrong ways -- by pirating and by building R&D facilities. He recognizes the pitfalls in pirating and questions the construction of R&D facilities -- because he contends it is not obvious that states are dependent on S&T for economic development. And, even if they are, a research institute may not be the answer. He reasons that, as a nation, we are not using the research we have. Transportation and communication are not limiting factors as in the past. Moreover, the majority of new research institutes have nothing to do with local industry, local public sector needs, or resources of the states in which they reside.

He advocates programs:

1. to train entrepreneurs to make better use of existing research;

2. to create the markets for the entrepreneurs -- expecially in light of the opportunities and needs of the public sector; and

3. to provide business services.

This can be done in several ways. The state can act as a middleman in getting business and inventors together; it can supply businesses with up-to-date technical information; the state, possibly by working through universities, could provide consultation to industries, manufacturers associations, and chambers of commerce; the state could provide better information on venture capital. In regard to this point, Mr. Schon says, "It seems clear that capital shortages are not the stumbling block for small business."

61. Schwitter, J. P., "Universities as Research Park Developers," Industrial Research, April 1965, pp. 73 - 78. (D, E)

This article examines the motives, the benefits, and the problems of university-backed research parks. The author traces their growth to four factors: Maturity of the industrial park concept since World War II, research upsurge that began about the same time, the desire of industry to locate in more attractive settings, and increasing movement of universities in research and industry. The principal sponsors of university research parks tend to be state institutions.

The research park can offer a number of benefits. The research park can spur other economic and industrial growth. It can expand the local tax base and increase revenues of existing commercial service firms. Consulting opportunities for the faculty and employment opportunities for students are other benefits. The universities offer facilities and services which enhance the research park. The university offers graduate and undergraduate courses for company employees, it serves as a source of new scientists and engineers, it provides library and special research facilities close at hand. Universities point to the industrial research complex as an indication of their interest in serving area industry.

On the other hand, critics of university involvement in research parks maintain that this contradicts the teaching and basic research objectives of the university.

62. Shapero, Albert, Richard P. Howell, and James R. Tombaugh, An Exploratory Study of the Structure and Dynamics of the R&D Industry, Stanford Research Institute, June 1964. (A, B, D)

This report sets forth the findings of Phase I of a three part study of defense R&D. The study concentrates on nontechnological factors which affect R&D performance, either directly or through the environment in which R&D is performed. The objective of Phase I was to develop a set of inferences and hypotheses concerning the structure and dynamics of defense R&D which would be tested in later phases. Data were obtained from national sources and field work in three R&D centers -- Denver, Tucson, and Orlando. Selected findings of particular interest are:

* The West Coast and the Northeast account for more than 70 percent of defense R&D prime contract awards, and two-thirds of all material purchases by prime contractors.

* A large defense R&D company moving into a previously non-R&D area will import two-thirds of its salaried workforce for at least ten years.

* Sources of salaried R&D workers are: 72 - 82 percent from other companies in the industry, 8 - 11 percent from government, and only 4 - 8 percent for educational institutions.

* Five major defense complexes account for almost 60 percent of all defense prime R&D contracts: Southern California, San Francisco, New York City-Northern New Jersey, Boston, and Washington, D. C.

* Large R&D contractors located outside major R&D complexes will buy only one-fifth of their material in their home state.

* Large R&D contractors are relatively independent of their local environment.

* Small R&D contractors are highly dependent on their local environment, particularly the local financial community.

* Local university graduate programs and research programs do not play a substantial role in attracting R&D industry to an area. Also, university study programs affect the attraction of only a small percentage (3 - 5%) of salaried R&D employees. Conversely, R&D companies have a positive effect on the development and growth of local universities.

* Differences in local taxes do not play an important role in R&D location.

* No one factor can be singled out as necessary and sufficient for the development of a defense R&D complex, but two factors which are necessary, but not sufficient, are: (1) the presence of R&D oriented entrepreneurs in the local community (or their attraction to it), and (2) the availability of local financial support.

* The award of large defense R&D contracts to organizations in a community is not sufficient in itself to generate the development of an R&D complex even over several years.

63. Shapero, Albert, Richard P. Howell, and James R. Tombaugh, <u>The Structure and Dynamics of the Defense R&D Industry: The Los Angeles and Boston Complexes</u>, Stanford Research Institute, November 1965. (A, B, D)

This report is the second phase of a study to develop a body of knowledge about the structure, organization and dynamics of the R&D industry in the United States. Conclusions and inferences include:

* The proportion of the industry's engineers and scientists having college degrees is increasing with time and the proportion of those holding graduate degrees is increasing more rapidly than the proportion of those holding bachelor degrees.

* The flow patterns of the industries salaried workers, particularly its engineers and scientists, are very highly correlated with the interregional migration patterns of the general U. S. population and include streams of flow among preferred routes to preferred destinations.

* A small percentage of the salaried workers in the local R&D industry take courses at a local university as compared with a higher percentage of those classified as engineers and scientists.

* Defense R&D companies have a positive effect on the development of local institutions of higher learning.

* The large defense R&D company is relatively independent of its local environment in regard to access to markets, sources of material, and sources of financial support.

64. Shapero, Albert, Kirk Draheim, and Richard P. Howell, The Development of a Potential Defense R&D Complex, Stanford Research Institute, July 1966. (A, B, D)

This report presents the findings of the third in a series of three studies conducted to develop a body of knowledge about the structure and dynamics of the defense R&D industry. The third phase tasted and validated inferences developed in the two preceeding phases and examined in detail the defense R&D industry in Minneapolis-St. Paul. Specific attention was directed toward: (1) How does a defense R&D complex develop, and (2) Why has not a larger defense R&D industry developed in the Midwest? The report has three major substantive sections: (1) Structure and Dynamics of Defense R&D Industry in the Twin Cities -- includes composition of the industry, its national ranking, manpower characteristics, and procurement patterns. (2) Factors Affecting the Development of the Twin Cities Defense R&D Industry -- includes the role of the financial community, the role of the R&D-oriented entrepreneur, the role of the local university, and analyses of company formations, failures, and spin-offs. (3) Speculations on Factors Related to the Development of a Defense R&D Compex -- includes characteristics of a complex, speculations on a development strategy, and comments on the Midwest and the Defense R&D industry.

65. Siegel, Irving H., "The Role of Scientific Research in Stimulating Economic Progress," American Economic Review, Vol. L, No. 2, May 1960, p. 340. (A, B)

Economic progress is characterized by three rising trends: an increase in output per capita; an increase in output per unit of input, expecially labor; an increase in the specific varieties of known available or actually used inputs, production processes, or final product. But, the author adds, research does not always contribute to these. Research does add to the stock of known and often usable specific inputs-outputs and processes. But it does not guarantee actual innovation and widening commercial use of rising output per capita or rising productivity. The main role of research is to multiply technical and economic opportunity. But the quality of entrepreneurship, market conditions, and other factors determine whether or not such opportunities will be realized. The author stresses that the influence of research on economic progress is not so unequivocal, automatic, and preponderant as the popular literature takes for granted."

66. "Small Colleges Bid for Military R&D Funds," Business Week, February 18, 1967. (B)

In a new project called Themis, the Defense Department has a program which will award research contracts to some of the nation's smaller colleges and universities. This is partly in response to charges it has played favorites among universities and partly in response to a Presidential appeal for broader federal R&D programs. Funding will be for 100 percent of chosen projects for the first year of the project, 67 percent for the second year, and 33 percent for the third year.

67. Smith, Spencer M., Jr., "Small Business and Innovation," Testimony before the Subcommittee on Antitrust and Monopoly of the Senate Committee on the Judiciary, May 1965. (B)

This testimony is based on the findings of a study directed by the author at the University of Maryland entitled, "Performance and Potential of Small Business in Research and Development Industries in Maryland and Metropolitan Washington." The study concluded that small business will continue to perform a very small percentage of the total R&D. On the other hand, it also questioned the view that large units are needed to produce innovations in products and services. In fact, many large prime contractors subcontract much work to smaller firms because the small firms can produce the desired results and often at lower cost. The study results also suggest that the potential of small business enterprises in R&D is far from being realized.

68. Solo, Robert A., "Gearing Military R&D to Economic Growth," Harvard Business Review, Vol. 40, November - December 1962, pp. 49 - 60. (A)

In this article Mr. Solo maintains that military R&D is not helping to stimulate the growth of the country and is, in fact, slowing it down. He supports this view by showing that output per man hour and number of patents issued are not keeping pace with the expenditures for R&D. One reason for this, according to Mr. Solo, is a diversion of brainpower from the civilian economy to space and military efforts. While he admits spillover may be useful he maintains it is not as valuable as before because military technology has far outstripped civilian technology and the two branches have less and less interaction. He concludes by saying that a new approach is needed to transmit military technology to the civilian economy.

69. Solow, Robert M., "Technical Change and the Aggregate Production Function," The Review of Economics and Statistics, Vol. XXXIX, No. 3; Harvard University Press, August 1957, pp. 312 - 20. (A)

In this article Solo attempts to determine the increase in output per capita that can be attributed to technical change as opposed to changes in capital investment. During the period of analysis (1909-49) Solo concludes that 87.5 percent of the increase in output per man hour was attributed to technological change. The increase occurred at a rate of about 1 percent per year during the first half of the period and 2 percent per year during the last half.

70. Stambler, Howard, "Manpower Needs in 1975," Monthly Labor Review, Vol. 89, No. 4, April 1965. (C)

The article is a forecast of manpower requirements by occupation during the decade ending in 1975. Important factors influencing the changing occupational structure of employment were stated to be: technological change, population growth, government policy, and labor-management practices. Total employment is expected to increase by one-quarter. Expectations for occupational groupings are as follows:

* Professional, Technical, and Kindred Workers - Fastest growing group since World War II. Trend will continue, with group as a whole increasing twice as fast as the average for all occupations. Requirements for scientists will grow slightly faster than need for engineers. Technicians will increase faster -- perhaps by two-thirds.

* Managers, Officials, and Proprietors - Group as a whole will increase slightly faster than average of all occupations, however, the number of proprietors will not increase.

* Clerical Workers - Group will increase by about one-third. This is a continuation of past growth rates for the group.

* Sales Workers - The increase of this group will be the slowest for any white-collar occupation but will be about equal to the average of all occupations.

* Craftsmen, Foremen, and Kindred Workers - This group will be the fastest growing of the blue-collar workers but it will only equal the average rate for all occupations.

* Operatives and Kindred Workers - Needs for semi-skilled workers will grow at slower than average rates. An increase of about one-sixth is expected.

* Industrial Laborers - This group has declined steadily as a percent of the working population in recent years. This trend is expected to continue. The total number will not change significantly from present levels.

* Service Workers - Increase of two-fifths is expected by 1975. This is the second fastest growing occupation group.

* Farm Occupations - A continuation of the past decline is forecasted. The number in the group may be one-quarter lower in 1975 than in 1964.

The overall effect is a clearly rising demand for workers with high levels of education and training. This demand is not confined to the more rapidly growing fields but to every broad occupational group.

71. "Stanford, Boom in Electronics in the San Francisco Bay Area was Ignited Down on the Farm," Science, Vol. 143, No. 3612, March 20, 1964, pp. 1305 - 1309. (A, D)

Stanford and University of California at Berkeley get credit for doing what MIT and Harvard have done for the Boston-Cambridge area. Stanford is viewed as the chief begetter of an electronics industry which in recent years has grown into an $800 million a year business employing 50,000 people. The strong connection between Stanford and the California electronics industry depends primarily on the university science and engineering faculties which are committed to instruction and research, but accustomed to collaborating with industry. Even more direct contact with industry and government has been afforded by two Stanford inspired off-campus enterprises: (1) Stanford Industrial Park and (2) Stanford Research Institute. An interesting note regarding both the research park and Stanford Research Institute were reasons for developing. Two reasons not previously mentioned in other material are (1) Stanford University would have to pay taxes on land not used for educational purposes. Thus, the reason for developing the research park and leasing the ground; (2) Stanford was subjected to post-war pressure to increase enrollment at a time when educational costs were rising. This was even more acute in view of the fact that plans were made to expand enrollment of graduate students who are much more expensive to educate than undergraduates.

72. Stone, Jack I., Education in the Upper Midwest Economies, Upper Midwest Research and Development Council, Technical Paper No. 9, January 1964. (C, D, E)

This report contains a survey of the economic aspects of education in the upper Midwest. The educational attainments of the region's present and future labor force are evaluated and the costs of education considered. Particular emphasis is paid to the concept of education as investment in human resources. The report presents action alternatives relating to education costs and future labor force quality.

73. Taylor, Donald W., Robert B. Fetter, and Thomas T. Holme, Should a Not-for-Profit Research Institute be Established in Connecticut, Yale University, New Haven, 1965. (D, E)

The purpose of this report was to determine whether a research institute should be established in Connecticut and, if so, what type of institute and what type of operating policies should it employ. It serves as a good example of the questions to be answered in considering establishment of a research institute. The authors conclude that a research institute should be established only if its objectives are among the first four listed:

1. Provide a payroll with attractive work and salaries.
2. Conduct research for the Federal government.
3. Conduct research for large companies regardless of their location.
4. Improve the image of the state and the cultural and intellectual atmosphere of the immediate area.
5. Conduct research for state and local governments.
6. Conduct educational activities of benefit to state industries.
7. Conduct research for medium- and small-size companies within the state.
8. Attract industries to locate within the state.
9. Create new industries within the state.

74. Terman, Frederick, E., "The Newly Emerging Community of Technical Scholars," Paper presented at the Colorado University-Industry Liaison Conference, Colorado Springs, November 4 - 5, 1963. (B, D)

The author believes that universities are becoming major economic influences in the nation's industrial life effecting the

location of industry, population growth and the character of communities. Universities are a natural resource just as raw materials, transportation, climate, etc. Faculty members typically do some consulting with one or more adjacent growth companies on subjects in which they have professional expertness, and they often set on a board of directors. Many professors of engineering and science serve on government advisory committees concerned with highly technical problems of national defense, space, etc., and they sometimes even get involved in international diplomacy.

By the same token, in the modern community of technical scholars, people in industry develop many close contacts with the academic activities in the community. The creative individuals who are doing interesting work in local companies frequently appear before seminar classes at the university. Junior employees of local companies in many cases are enrolled in university. The activities of both the industry and the university react with each other, both contributing to the university's progress and influencing the direction it takes.

75. Tomkin, Leo S., "The Government's Role in University Research," Industrial Research, April 1965. (D, E)

Growing federal research involvement in American higher education has produced tangible and advantageous results. Research funds help colleges and universities recruit and retain faculty personnel. Highly competent students are attracted to the recipient schools. Also, federal funds help students defray the growing costs of higher education. Further benefits of federal funds include the acquisition of highly technical and expensive equipment; expensive building construction is facilitated and often completely financed with government research funds. But with all these benefits certain problems have arisen bearing on the university-government relationship. Congressional hearings, especially those of the Elliott and Daddario committees, have uncovered some of these problems. They include priorities and the extent of federal involvement, effectiveness of research performed, science versus education, research versus teaching, geographic dispersion of research spending, red tape and bureaucracy, indirect cost to the university. The universities must consider all of these problems in light of their continued competition for federal research funds. According to Mr. Tomkin, those responsible in institutions of higher learning must take a more active role in decision making process involving federal funds, they must be aware of the changing Washington spirit, and they must know how to plead their cause before the Congress.

76. U. S. Arms Control and Disarmament Agency, <u>Defense Industry Diversification</u>, a report prepared by John S. Gilmore and Dean C. Coddington, University of Denver Research Institute (Washington: Government Printing Office), January 1966. (A)

This is a report on the domestic economic implications of reductions in defense demand. The objective of the study was to prepare a series of case studies regarding defense industry's experience in diversifying from defense to nondefense markets. The major emphasis was placed on the marketing and management decision-making aspects of diversification. Several points regarding diversification were brought out. These are: (1) successful diversification needs the commitment of top management to the program; (2) the major challenge in the management of defense diversification is in showing ingenuity in the marketing fields as well as in technical matters; (3) diversification efforts usually market to customers in a different business environment and the firm must find means -- economical and effective -- to open windows on this commercial world; (4) close control of marketing expenses essential; (5) a substantial time lag occurs from the start of diversification programs to the break-even point or to the completed integration of an acquisition; and (6) there are many parties of interest in the defense diversification process and their interests may conflict.

77. U. S. Congress, House Committee on Government Operations, <u>Conflicts Between the Federal Research Programs and the Nation's Goals for Higher Education</u>, 89th Congress, 1st Session, U. S. Government Printing Office, Washington, D. C., October 1965. (F)

This report on a study of the research and technical programs subcommittee focuses on conflicts between federal research programs and the goal of higher education. The committee determined that there were in fact three conflicts: (1) the present use of scare manpower; (2) the present use of manpower resources and investment for future manpower resources; and (3) the demands of R&D focused primarily in the natural sciences. In answer to these conflicts the committee recommends (1) maintaining scientific manpower data; (2) weighing priorities between teaching and research; (3) encouraging researchers to teach; (4) instituting science teaching fellowships; and (5) institute a Presidential award for outstanding undergraduate teachers.

78. U. S. Congress, Senate Committee on Labor and Public Welfare, Convertibility of Space and Defense Resources to Civilian Needs: A Search for New Employment Potentials, Compiled for the Subcommittee on Employment and Manpower, Volume 2 of Selected Readings in Employment and Manpower, 88th Congress, 2nd Session, Washington, D. C., U. S. Government Printing Office, 1964. (C)

The subcommittee concluded six months of hearings on employment and manpower with investigations devoted to the impact of defense and space efforts on employment and economic growth. This report is an extension of those hearings. An attempt was made to assess the nature and extent of the impact which defense and space have had upon national employment and manpower and the various regions, industries, and communities. Regarding national employment it was determined that about 9 percent of all U S. employment was in federal and industrial defense-related activities in 1962. Distribution by industry showed that employment in the four leading defense-related industries represented 2-1/2 percent of manufacturing employment. These four were ordnance, aircraft, missiles, and ship and boat building, and electrical machinery. Geographic distribution indicated that the states most affected are Alaska, Hawaii, Washington, the D. C. complex (Maryland and Virginia) certain New England states -- Connecticut and Massachusetts --, some Mountain states -- New Mexico and Utah --, and several other states -- Oklahoma, Kansas, Alabama, Georgia, and South Carolina.

79. U. S. Congress, House Committee on Science and Astronautics, Government, Science and Public Policy, Panel on Science and Technology, 89th Congress, 2nd Session, Washington, D. C., U. S. Government Printing Office, 1966. (B)

A report on a panel discussion on science and technology -- the seventh in a series. The purposes for calling this panel were to identify spheres of scientific research which offer exceptional promise for our national security and welfare, and which need further attention, strengthening, or shift in emphasis, to discuss current methods for conducting research, to provide information concerning availability of scientific manpower and on educational needs, to provide information on matters of international co-operation and organizations concerned with space, and to maintain channels of communication between the Congress and the scientific community.

The three specific topics upon which papers were presented and discussed were: (1) The Role of Government in Science Education,

(2) Science and Social Change, and (3) Science as an Element of Economic Growth. The last topic includes a very pertinent discussion and commentary on steps being taken in Connecticut to promote science based growth.

80. U. S. Congress, House Committee on Science and Astronautics, Report on the Geographic Distribution of Federal Research and Development Funds, 88th Congress, 2nd Session, U. S. Government Printing Office, Washington, D. C., October 1964. (B)

This report concentrates on two questions explored in the subcommittee hearings (commonly referred to as the "Daddario hearings ings"): (1) is the geographical distribution of federal research funds uneven in any pronounced degree, and (2) if so, is some corrective action indicated? Yes, according to the committee. However, the report does not discredit either the government agencies responsible for the distribution of research funds, or the industrial and non-profit recipients of these funds. Nonetheless, the problem is considered to be severe enough to warrant continued attention by Congress and the Executive Branch. In undertaking remedies, the committee concluded, care must be taken not to detract from or penalize those institutions and areas which, due to their own wisdom and effort as well as their favorable location, have built the kind of research competence needed to attract federal grants and contracts. The committee also concluded, however, that there was danger in redistribution -- that a more uniform geographic distribution of federal research funds, as they are currently constituted, cannot be achieved without some danger of degrading the results of the research desired, and, more importantly the applications and end items required by the mission-oriented agencies. The committee felt that any short range attempt for a more uniform geographic distribution of funds should be directed towards increased utilization of the scientific and technical competence of institutions with good facilities and talents which are not now participating to any substantial degree in federal research programs. This report includes supporting data relating to the geographic distribution of federal R&D runds.

81. U. S. Congress, House Select Committee on Government Research, Federal Research and Development Programs, Parts 1 and 2, (Hearings) 88th Congress, 1st and 2nd Sessions, U. S. Government Printing Office, Washington, D. C., 1964. (B)

The purpose of these hearings, referred to as the Elliott hearings, was to examine and investigate the numerous research programs

being conducted by the various agencies and departments of the Federal Government. Special attention was given to: (1) the overall total amount of annual expenditures on research programs; (2) what departments and agencies of the government are conducting research and at what costs; (3) the amounts being expended by the various agencies and departments in grants and contracts for research to colleges, private industry, and every form of student scholarships; and (4) what facilities exist for coordinating these research programs, including grants to colleges and universities as well as scholarship grants. The witnesses included leaders in the field of science, government, public affairs, industry, and labor.

82. U. S. Congress, Senate Select Committee on Small Business, Impact of Defense Spending on Labor-Surplus Areas, U. S. Government Printing Office, Washington, D. C., August 1963. (A, C)

The hearings and report of this subcommittee, the Humphrey Committee, show that shifts in defense spending from one region of this country to another have created a significant number of distressed areas. This report suggests that the government can anticipate changing trends in defense spending and other areas -- i.e., automation -- and respond to them with positive action. Additional research and studies recommended included the investigation of the relationship of the letting of R&D contracts and the placement of prime contracts, the publication of statistics relative to productive potential in labor surplus areas useful to firms considering placing new facilities in labor surplus areas, issuing complete reports on agencies' implementation of DMP No. 4, and expand the responsibility of the Office of Emergency Planning to include preparation of studies and suggestions to improve the long-range health of the economy.

83. U. S. Congress, Senate Subcommittee of the Select Committee on Small Business. The Role and Effect of Technology in the Nation's Economy, (Hearings) 88th Congress, 1st Session, May - December, 1963. (A)

These hearings, often referred to as the Humphrey hearings, were held in order to review the effect of government research and development on economic growth. The reasons for the investigation included:

1. The fact that human resources are becoming more important than natural resources in the national economy;

2. Technical capability is the primary force in our economic growth;

3. The prosperity of regions is also dependent on human rather than natural resources.

The purpose of this review was to examine conditions that would encourage the more widespread and more intense use of technology for economic growth, to find ways to encourage technical entrepreneurship, and to better understand the status and utilization of the technical resources of the nation.

84. U. S. Congress, Senate Committee for Labor and Public Welfare, The Impact of Federal Research and Development Policies Upon Scientific and Technical Manpower, Report and Recommendations of the Subcommittee on Employment, Manpower, and Poverty, 89th Congress, 2nd Session, U. S. Government Printing Office, Washington, D. C., 1966. (C)

A report on the subcommittee's investigations on the effects of federal research and development policies upon universities, industries, and ultimately upon the utilization and employment of scientific and technical manpower. General findings were: (1) There is a marked and persistent concentration of R&D funds, (2) R&D funds act as an important magnet drawing scientific and technical manpower to the area or establishment in which the funds were placed, (3) there is evidence to support changes in policy and present concentration may not serve the best interests of the country and its regions, (4) the subject warranted further congressional study. The report includes data on the distribution of federal R&D Funds, discusses effects of federal R&D on scientific and technical manpower, discusses effects of federal R&D on local and regional development, and examines deficiencies in R&D programs and the causes of these deficiencies. The report concludes with recommendations for a national policy on distribution of R&D funds, presents a 10-year redistribution plan, and presents a series of actions to assist this process of redistribution.

85. U. S. Congress, Senate Committee on Labor and Public Welfare, Scientific Manpower Utilization, Hearings before the Special Subcommittee on the Utilization of Scientific Manpower, 89th Congress, 1st and 2nd Sessions, Washington, D. C., U. S. Government Printing Office, 1967. (C)

The testimony offered in these hearings was concerned with a bill designed to facilitate and encourage the utilization of the scientific, engineering, and technical resources of the nation in meeting urgent problems facing the nation or localities within the nation, by promoting the application of systems analysis and systems engineering approaches to such problems. The pioneering studies sponsored by the State of California and conducted by aerospace firms received particular attention. Testimony is included on Lockheed's study of a Statewide Information System, Space-General's study of Crime and Deliquency Prevention and Control, and North American's Transportation System Study. Application of systems analysis to the operation of selected federal agencies is also covered.

86. U. S. Department of Commerce, Office of State Technical Services, First Annual Report: Fiscal Year 1966, Washington, D. C., January 1967. (E)

This report describes the functions and activities of the Office of State Technical Services (OSTS) during its first year operation. The report presents a brief description of the objectives, organization, administration, plans and programs of the agency and designated agencies at the state level. Of particular value are the lists of state-designated agencies and appropriate state officials and working contacts, as well as lists of the advisory council members for each state.

87. U. S. Department of Commerce, Office of State Technical Services, Technology Transfer and Innovation: A Guide to the Literature, No. STS-104, August 1966. (E)

This report is divided into two parts: a review section that categorizes and highlights some of the ideas in the literature and an excellent annotated bibliography. The review section, in turn, is in four parts which deal with (1) the aspects of technological change, (2) technology transfer, (3) factors encouraging innovation, and (4) congressional hearings regarding problems in technology transfer.

88. U. S. Department of Commerce, Technological Innovation: Its Environment and Management, U. S. Government Printing Office, Washington, D. C., 1967. (A, B, D)

This report of the Panel on Invention and Innovation focuses on three factors affecting invention and innovation -- competition, taxation, and finance. While no major revisions in existing laws were recommended, the Panel concluded that taxation policy could be altered to give more encourgagement to inventors and innovators, and specific recommendations to this effect were made. The Panel also concluded that there was no shortage of venture capital for new research-based enterprises, but more information regarding that which is now available is needed.

89. U. S. Department of Labor, Bureau of Labor Statistics, Technological Trends in Major American Industries, Bulletin No. 1472, U. S. Government Printing Office, Washington, D. C., February 1966. (A, C)

This report, which extends and updates a previous report published in 1964 entitled Technological Trends in 36 Major American Industries, appraises some of the major technological changes emerging among American industries and projects the impact of these changes over the next five to ten years. The bulk of the report is devoted to discussion of developments in specific industries under the following headings:

1. Summary of outlook through 1970.

2. Outlook for technology and markets.

3. Manpower trends and outlook.

4. Some issues and examples of adjustment.

A list of selected references relating to the individual industry is included at the end of each industry section. A more lengthy, general bibliography appears at the conclusion of the report. This report should serve as a most useful reference summarizing current technological developments in specific industries.

90. U. S. Department of Labor, Bureau of Labor Statistics, Technician Manpower: Requirements, Resources, and Training Needs, Bulletin No. 1512, Government Printing Office, Washington, D. C., June 1966. (C, D)

This report presents the results of a study of current and future technician manpower requirements conducted by the Bureau of

Labor Statistics with the support of the National Science Foundation. Emphasis is on the ways in which persons are trained for technician jobs, and on the projected supply and demand for these workers. The requirements for technicians (based on alternative assumptions) range from 877,000 to 1,300,000 by 1975. The alternative projections of supply range from 475,000 to nearly 1,040,000. Graduates of post-secondary preemployment technician training programs are expected to have excellent employment opportunities, as are those individuals with other types of specialized training.

91. Weidenbaum, Murray L., Some Regional Impacts of the Expansion in Domestic Government Programs, Working Paper 6518 prepared for the Seventh Annual Conference, Center for Economic Projections, National Planning Association, October 15, 1965. (A, B)

The major theme expressed in this paper is that the current expansion in the Great Society and other domestic civilian programs of the Federal government is resulting in a shift in the geographic distribution of federal funds. Low-income states receive a larger than proportional share of these programs whereas the higher income states receive a larger than proportional share of defense and space funds. Mr. Weidenbaum then concludes "that any shift in the federal expenditures from defense to non-defense activities, assuming no fundamental alteration in the geographic distribution patterns of individual public programs tends to narrow income inequality among the various regions of the United States."

92. Weidenbaum, Murray L., Shifting the Composition of Government Spending: Implications for the Regional Distribution of Income, Working Paper 6520 prepared for the annual meeting of the Regional Science Association, November 1965. (A, B)

This is a preliminary report on the allocation of Federal government expenditures in relation to the regional distribution of income. Previous work has followed two different lines of approach. Public finance studies have analyzed the geographic allocation of federal expenditures and ignored the impact resulting from the change between defense and nondefense expenditures. Defense and disarmament studies have pointed out the extreme geographic concentration of defense work but have not dealt with the effects of defense reductions or disarmament on regional income distribution. Because these do not focus on the regional distribution of income this study links these two approaches to show the effects on income distribution. The implications following from the analysis show that expansions in the

Great Society programs and other domestic civilian programs are resulting in a shift in the geographical distribution of income which should work toward a regional change and greater income equality.

93. Weidenbaum, Murray L., "Measurements of the Economic Impact of Defense and Space Programs," American Journal of Economics and Sociology, Vol. 25, No. 4, October 1966, pp. 415 - 426. (A)

The article focuses on statistical information needed to analyze the economic impact of defense and space expenditures. Three aspects of the problem are covered: the current stock of information, additional information that will soon become available, and the major gaps that need to be filled. According to the author, the greatest need is for more industrial and regional data on income and employment generated by defense/space expenditures. A second need is for information of adjustments at the local level to changes in the level and composition of defense and space spending. A third area of need is for information relating to transfer of defense and space technology to the civilian sectors.

Using what data are available, the author arrives at the following conclusions:

1. About one-tenth of the nation's resources is being devoted to national security programs.

2. Much of these resources tend to be located in relatively few industries and regions.

3. The industries are predominantly the high-technology ones -- aircraft and electronics, plus supporting firms in such fields as ordnance and instruments.

4. The regions most heavily involved are predominantly the areas where these industries tend to cluster -- the West Coast and the highly industrialized states of the Northeast.

94. "What the Space Race Will Do to You," Nation's Business, October 1962, p. 31. (A)

To assess the broader consequences of the battle for supremacy in space the author interviewed men in government, legislators, economists, and research specialists to discuss the major problems and their potential solutions. Two points stood out: (1) By the very breadth

of its program, government gains unprecedented possession and control of the vital tools for industrial progress; and (2) there is a forced draft of comparatively scarce scientists and engineers to concentrate on research not directly related to the needs of the economy while foreign competitors concentrate on economic goals. The author concludes that "Students of the space program question whether the technology it produces will benefit the economy to the extent claimed without a major reallocation of resources to permit widescale innovation undertaken with the civilian needs uppermost in mind. . ."

95. "Where Does the Money Come From," New England Business Review, January 1965. (D, E)

This article summarizes the results of a study based on interviews with 25 initial investors in new scientific or engineering firms in the New England area. The study focuses on the initial capitalization of new technically oriented firms in contrast to later financing after they have become established. Three major sources of initial equity capital were called out: (1) Affluent individual investors -- this was by far the most important source. Motivations were typically a combination of economic and non-economic reasons with the possibility of long-term capital gains being the dominant economic motive. (2) Venture capital organizations such as Small Business Investment Companies - they were a relatively unimportant source. SBIC's typically had limited investment capacity and were adverse to risk assumption. There were significant exceptions. SBIC's did provide valuable communications channels and referral functions. (3) Established industrial corporations -- these were mature organizations generating cash faster than investment opportunities and wishing access to new technologies. In deciding to risk funds the investors considered: (1) the people more than the venture situation, (2) demonstration of a growing market, (3) the idea had to be developed beyond the concept stage through prior product or process development, and (4) amounts invested in a situation rarely exceeded $50,000 to $200,000.

APPENDIX B

SELECTED REGIONAL INSTITUTIONS AND ORGANIZATIONS

A number of different types of institutions and organizations have been established at the regional, state, and local level for the purpose of stimulating and upgrading scientific and technological activity. Many of these have been referred to in the body of the report. The purpose of this Appendix is to provide a brief description of the objectives, characteristics, and activities of selected organizations. We have not attempted to develop an exhaustive list of regional organizations. Instead, the intent is merely to illustrate types of groups by presenting examples.

Name: Center for Industrial Research and Service
Iowa State University

Contact: Waldo W. Wegner, Director

Address: 202 Building E
Iowa State University
Ames, Iowa 50010

Background: The Center for Industrial Research and Service (CIRAS) is a service organization to existing Iowa industries. It was established in 1963 as a function of the College of Engineering. In 1966 it became a part of Iowa State University extension.

CIRAS is headed by a director; a professional headquarters staff is maintained as well as a four-man field staff. The headquarters office maintains a retrieval file on all Iowa industries; the service professions such as engineers, architects, testing laboratories, advertising agencies, etc.; professors and other expertise which Iowa industry and business might expect to use in their daily operations.

Functions: The basic service of CIRAS is to place the industry or business with a problem in touch with the most likely service organization or professor who would be able to give them an answer to this problem. This is accomplished through the daily contact of industry by the field representatives and through the use of a bi-monthly newsletter, and through constant verbal contact with service organizations by members of the CIRAS staff. Other activities include the administration of the State Technical Services Act for the State of Iowa; the administration of the Professional Development Service Center; and the administration of the Iowa Development Commission Foundation, Inventors and Innovators Program for the State of Iowa.

Name: Connecticut Research Commission

Contact: John S. Burlew, Director

Address: 18 Trinity Street
Hartford, Connecticut 06115

Background: The Connecticut Research Commission, an agency of the state, was established in June 1965 with the responsibility for the promotion and support of research activities that will benefit the state and its citizens. The legislation was the result of the recommendations of the Connecticut Research Advisory Committee -- previously appointed in 1961. The Commission receives appropriations from the General Assembly for the support of research and administrative expenses.

Functions: The duties of the Commission include the following:

(1) Conduct a continuing review of the research, scientific and technological programs of agencies of the state.

(2) Identify problems, matters or areas relevant to the interest and welfare or betterment of the citizens of Connecticut which should be made the subject of research.

(3) Initiate or support research regarding such problems, matters or areas through any agencies of the state, through the University of Connecticut, through any private institution in the state which is engaged in research, and through any joint, collective, regional or inter-disciplinary group or organization in the state which is engaged in research, or which is composed of institutions engaged in research.

(4) Review the published findings of research in Connecticut and elsewhere and propose ways to translate such findings into more jobs in Connecticut industry.

(5) Make recommendations to achieve more effective utilization of the research, scientific and technological resources and facilities of state agencies.

(6) Collect and disseminate information about research, scientific and technological programs of the Federal Government.

(7) Provide an information service about institutions engaged in research activities in the state.

(8) Provide an advisory service on research, science and technology to the governor, the general assembly, and other agencies of the state.

(9) Publish documents and reports in support of these functions.

(10) Maintain liaison with all private organizations in Connecticut engaged in research activities and with research councils organized to promote research activities, and render to such private organizations and research councils coordinating and advisory services which they may request.

Name: Colorado Industrial Research Campus

Contact: James B. Shea, Jr., Executive Vice President

Address: Colorado Building
Suite 618
1919 14th Street
Boulder, Colorado

Background: CIRC is a for-profit research and industry park located near the University of Colorado. Included are 750 acres, 50 of which are reserved for the University of Colorado. CIRC was established because of: the increasing science orientation of American manufacturing industry, vastly expanded private and publish expenditures for research, and the increasing awareness of the importance of an environment as a factor in attracting and holding scientific personnel and skilled workers.

The campus has been divided into the four areas depending upon the use:

(1) Research, development, and prototype manufacturing activities,

(2) Light manufacturing,

(3) Corporate offices, regional offices, and engineering and other professional services, and

(4) A service center.

Name: Council of Economic Growth, Technology and Public Policy of the Committee on Institutional Cooperation

Contact: Carlisle P. Runge, Director

Address: 2569 University Avenue
Madison, Wisconsin 53705

Background: The Council on Economic Growth, Technology and Public Policy is a research-action group formed in 1966 by the Committee on Institutional Cooperation (CIC) to draw upon the expertise among the faculties of eleven of the foremost universities of the Midwest to further the economic and social well-being of the region.

Representatives and observers from the several Big Ten Universities* and the University of Chicago -- which comprise the CIC -- sit on the Council. They oversee a small, full-time staff, headed by a director, which is headquartered in Madison, Wisconsin. The Council is being supported initially by the participating universities. It is planned that the Council's program will be supported in the future from extramural sources.

Functions: The CIC organized the Council to assemble selected resources of the member institutions in interdisciplinary, problem-oriented research and action programs designed to contribute to the long-range economic productivity and social welfare of an urban and industrialized society. To fulfill its purposes, the Council is proceeding to establish a program of studies and systems analyses aimed at increasing the understanding of the problems and potentials that characterize the Midwest. Such analyses will be aimed at enhancing the means for aiding decision makers in devising actions for regional development. Teams of problem solvers from relevant disciplines and from two, three or more of the CIC universities are being assembled to address themselves to the problems and potentials in the fields of transportation, water resources, technological innovation and development. Other working groups are to follow, including one in agriculture. The Council is also assisting in an interinstitutional committee on urban and regional design.

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* University of Illinois, Indiana University, University of Iowa, University of Michigan, Michigan State University, University of Minnesota, Northwestern University, Ohio State University, Purdue University, and University of Wisconsin.

Name: Denver Research Institute

Contact: Shirley A. Johnson, Jr.
Director

Address: 2050 Eliff Avenue
Denver, Colorado

Background: Denver Research Institute, established in 1947, is an integral part of the University of Denver and was established to broaden the research activities of the University. DRI provides a flexible organization which permits scientists and engineers the opportunity to utilize past experience while working progressively on the forefront of new knowledge.

The primary objectives of the research activities conducted at the Institute are:

(1) To advance human knowledge;

(2) To promote and stimulate a climate of intellectual curiosity and inquiry;

(3) To provide a mechanism for technical assistance to individuals, industry, private groups, and government at all levels;

(4) To train research workers, and particularly graduate and postdoctoral students, in the techniques of modern research;

(5) To vitalize the teaching processes of the University within the appropriately related academic disciplines; and

(6) To promote and advance the public interest and welfare.

<u>Name</u>: Iowa State University
Engineering Research Institute

<u>Contact</u>: D. R. Boylan, Director

<u>Address</u>: Iowa State University
Ames, Iowa 50010

<u>Background</u>: The Engineering Research Institute (Engineering Experiment Station until 1966) at Iowa State University is the research arm of the College of Engineering. Included in its program are:

(1) The initiation and establishment of active research in all departments of the College of Engineering, including interdisciplinary research programs.

(2) Support for the graduate program in the various departments through research funds.

(3) Opportunities for staff development through research programs.

(4) Dissemination of information on new technology, processes, devices, and engineering principles resulting from the research conducted by the Institute.

(5) Service to industry and government agencies by a contract research program.

(6) Provision of support facilities for the conduct of research.

Name: Frontiers of Science

Contact: Dr. James G. Harlow, Dean
College of Education

Address: University of Oklahoma
Norman, Oklahoma

Background: The Frontiers of Science Foundation was founded in September 1955. The initial objectives of this organization were three:

(1) To improve education;

(2) To improve public awareness of science and technology; and

(3) To improve research within the state.

Functions: The major activities of the Frontiers of Science Foundation have been in the area of symposia, particularly for high school students. These have covered a variety of scientific subjects and have been quite successful. The Foundation agrees to put up the money and selects a subject. An appropriate professional society is then selected to run the symposium.

Other programs include:

(1) Seed money grants for various purposes, including the Oklahoma City Educational TV station, the Oklahoma State University's traveling science lab which tours the state, and for the Oklahoma University computer layout study;

(2) Educational area activities -- they conducted the first state-wide aptitude test in the nation involving 60,000 students, were instrumental in introducing the modern math curriculum, and are now introducing the modern science curriculum; and

(3) Research -- they have made several small grants to date and are trying to tie the research community together throughout the state.

Name: Graduate Research Center of the Southwest

Contact: Dr. Lloyd V. Berkner, President

Address: 2400 N. Armstrong Parkway
Dallas, Texas

Background: The Graduate Research Center, including the Southwest Center for Advance Studies, with its postdoctoral research laboratories, was established on the premise that there is the need for direct assistance to industry in the general area of quite advanced scientific studies which would provide the connecting link between industry and the very basic and advanced research laboratory.

Functions: A primary objective of the Graduate Research Center is the enhancement of community awareness of the importance of graduate education and research to the economic and cultural welfare of the region. The purpose of the Center is to act as a focus for many simultaneous efforts to achieve a distinguished graduate education program in the region.

It is expected that the Center will concentrate more of its attention on the postdoctoral center of advanced research and the center of advanced study but will have within the same organization both applied economic research and applied engineering research to interpret and apply the scientific information to the needs and to the opportunities of industry.

Name: Industrial Development Division
Engineering Experiment Station
Georgia Institute of Technology

Contact: Ross W. Hammond, Chief

Address: 1132 West Peachtree Street
Atlanta, Georgia 30309

Background: In the mid-1950's, it became apparent that there was a scarcity of strong development agencies in Georgia, especially those active in the field of industrial development research. In an attempt to fill this vacuum, the Industrial Development Division was organized in July 1956, and has grown steadily in the intervening years. It is one of seven divisions of the Engineering Experiment Station of Georgia Tech. The Division's staff of 70 represents a diversity of academic and business backgrounds which result in an interdisciplinary team capable of applying varied experience and knowledge to problem solving. The overall objective of the Division is to stimulate and advance industrial and economic development primarily in, but not restricted to, the State of Georgia.

Functions: To achieve this economic development objective, a great variety of programs and activities are conducted. These include:

(1) Market research and feasibility studies to identify manufacturing opportunities;

(2) Analysis and evaluation of location factors;

(3) Management guidance and technical assistance to prospective and established concerns;

(4) Surveys of manufacturers;

(5) Collection, analysis, and evaluation of data relating to manpower resources;

(6) Analysis of the state's economy;

(7) Industrial development training and internship programs for domestic and overseas interns;

(8) Industrial extension services through seven field office operations;

(9) Analysis of community resources;

(10) Technical assistance to community development;

(11) Workshops and seminars on community and industrial development;

(12) Technology transfer activity under the State Technical Services Act;

(13) Direction of the Georgia Certified City program;

(14) Technical assistance to urban officials in overcoming community liabilities;

(15) Selection and evaluation of industrial sites and districts;

(16) Development of an economic development data center;

(17) Preparation of bibliographical materials; and

(18) Preparation of special guides and directories.

Over the years the Industrial Development Division has had a considerable impact on the industrial development of Georgia. Many of the market analyses have been the basis for establishing manufacturing plants in the state and the management and technical assistance has been provided to more than 1,000 Georgia concerns.

Name: Industrial Liaison Service
Nassachusetts Institute of Technology

Address: Cambridge, Massachusetts

Background: The Industrial Liaison Service at the Massachusetts Institute of Technology is a center for dissemination of scientific knowledge to the industry. It is somewhat unique in that corporations contribute unrestricted funds to MIT for basic research projects. This contribution, however, entitles the company to receive the published project reports and have access to MIT Research Programs. Two other functions include:

(1) Conducting symposia on varied subjects, and

(2) Holding conferences to discuss research projects before publication.

Finally, through the MIT Division of Sponsored Research, a referral or clearinghouse function is performed. The Division helps obtain professors to conduct industry projects or act as consultants.

Name: Midwest Research Institute

Contact: Perry L. Bidstrup
Vice President for Program Development

Address: 425 Volker Boulevard
Kansas City, Missouri 64110

Background: Midwest Research Institute was established in 1944 by a group of local business and civic leaders who believed that the application of scientific research to industry was bound to become a key factor in the economic and social growth of the Middle West. The stated objectives of the founders were to establish an institution -- independent and not-for-profit -- to do research for regionally-based industry and for smaller companies without access to research, to do research for state and local governments in the region, and to apply defense technology to the problems of peace and the civilian economy. Research for individuals; industrial firms, large and small; groups of companies; associations; and government at all levels is conducted by the Institute's five technical divisions: Chemistry, Biological Sciences, Engineering, Mathematics and Physics, and Economic Development.

In addition, the program of MRI has been expanded to include the gathering, assessment and dissemination of research results wherever they are available. The program calls for the establishment of information centers in specialized fields and an intensification of MRI's relationship with universities in a cooperative program to improve graduate education and increase research capabilities. MRI is one of the 12 regional dissemination centers established under the NASA Office of Technology Utilization.

Name: Mississippi Research and Development Center

Contact: Dr. Kenneth Wagner, Director

Address: P.O. Drawer 2470
Jackson, Mississippi 39205

Background: This Center was established by an act of the Mississippi state legislature in 1964 for the purpose of doing the analytical work necessary to establish methods for raising the standard of living in Mississippi. Activities of the Center include the following:

(1) Market Analysis: The Market Analysis and Industrial Location Division concentrates its efforts on identifying the "best bets" for new manufacturing and other payrolls throughout the state. Market analysis and product feasibility studies, as well as industrial location analyses are tailored to the individual company's needs. The industrial economics research necessary to supply background and supporting data will also be carried out.

(2) Management Services: The Management Services Division concentrates on providing management and technical assistance to established companies to help them expand and diversify. Designed to fill a void which consulting firms cannot fill, the work done by this Division will be limited to a maximum of five man-days for any one company. Larger problems will be referred to management or engineering consulting firms.

(3) Community Development: The Community Development and Planning Division is concerned with four major tasks: (1) auditing the economic resources of communities throughout the State; (2) analyzing each community's resources to determine its strengths and weaknesses; (3) providing the engineering and planning services necessary to help each community program the activities necessary to eliminate weaknesses identified by the research; and (4) long-range planning for the State.

(4) Information Services: To provide one of the key support services required for the work of the Center and of development agencies throughout the State, an Information Services Division has been established. This data center is designed to meet the information needs of State, regional and local development agencies, units for the University System, and other colleges and State agencies. It serves as a "clearinghouse" for all research carried out within the State, in addition to serving as a depository for all data compiled by the Center's staff on the economy of Mississippi.

(5) Computer Facility: A computer facility will be established to handle the data processing and retrieval needs of agencies throughout the State. This facility will be designed to provide the most efficient possible installation not only for the staff of the R&D Center and the Universities Center, but also to meet the computer needs of any other agencies that may wish to collaborate on computer problems.

(6) Manpower Resources: The analysis of the State's manpower resources, including the assessment of available personnel and skills, determination of the skills required to meet the manpower needs of business and industry, and analysis of any special training programs or facilities which may be necessary to expedite the development of the State's economy will be the responsibility of the Manpower Resources Division. The staff of this Division will work closely with all educational units of the State in an effort to assist them in the development of educational and training programs which can best meet Mississippi's economic development needs.

Name: North Star Research and Development Institute

Contact: Dr. John W. Clegg
President

Address: 3100 Thirty-Eighth Avenue, So.
Minneapolis, Minnesota 55406

Background: North Star Research and Development Institute was started in 1963 under the co-sponsorship of the University of Minnesota and the Upper Midwest Research and Development Council. Although an independent corporation, the Institute maintains close professional ties with the University staff, and University scientific and engineering specialists are available to North Star on research problems of mutual interest. The purpose of the Institute is to:

(1) Conduct scientific research in the physical, biological, and social sciences; engineering, and the mechanical arts;

(2) Add to the general body of scientific knowledge;

(3) Contribute to the scientific education of students; and

(4) Aid in accelerating growth of the economy.

Name: Oak Ridge Associated Universities

Address: Resource Development Office
Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37830

Background: Oak Ridge Associated Universities is a non-profit corporation established in 1946. It is comprised of 41 southern universities and colleges. The Association administers a wide variety of educational and research programs under a direct contract with the U.S. Atomic Energy Commission. These include:

(1) The AEC's special fellowships in nuclear science and engineering and health physics;

(2) Training courses for scientists and engineers in radioisotope techniques;

(3) Medical research devoted to the use of radioactive materials in the diagnosis and treatment of various diseases;

(4) Operation of the American Museum of Atomic Energy in Oak Ridge and the AEC's traveling exhibits program.

The Association also carries out programs of scientific research and education for the National Science Foundation, National Institutes of Health, National Aeronautics and Space Administration and other agencies.

Name: Office of University-Industry Relations
University of Colorado

Contact: Eric Schmidt, Director

Address: University of Colorado
Boulder, Colorado 80302

Background: The Office of University-Industry Relations was established by the university regents in 1964. This organization is a direct outgrowth of the 1963 university-industry liaison conference which stressed the lack of and need for an organized relationship between industry, the state government, and the university, and which emphasized the need to involve faculty members in service activities. University policy favors consulting by the faculty, joint use of equipment and laboratories, and the holding of seminars to keep industry abreast of advanced technology and science.

Functions: The functions of the Office of University-Industry Relations include:

(1) Handling inquiries from industry for information about university activities;

(2) Administering the Colorado State Technical Services Program;

(3) Responsibility for planning and administering the University's role in the new Colorado Industrial Research Campus; and

(4) Promotion of Colorado as a location for industry.

Name: Regional Industrial Development Corporation Industrial Development Fund

Contact: E.R. Weidlein, President

Address: 471 Union Trust Building
Pittsburgh, Pennsylvania 15219

Background: The RIDC Industrial Development Fund was established to encourage industrial and scientific growth in nine Southwestern Pennsylvania counties. The RIDC Industrial Development Fund is a privately owned corporation having a public purpose and is financed by shareholders, banks, savings and loan associations, and insurance companies. The functional purpose of the Fund is to make loans to new or expanding industry in the area, when and if such credit is not otherwise available from conventional lending sources. A Scientific and Research Advisory Group of the Regional Industrial Development Corporation is consulted by the Fund when considering loans that require technical advice.

Name: Research and Design Institute

Contact: Ronald Bechman, Director

Address: P.O. Box 307
Providence, Rhode Island

Background: The Research and Design Institute was formed in 1966 as a nonprofit contract research organization. Its principal purpose is to combine varied design skills with the social and behavioral sciences and with certain technical disciplines to produce improved understanding and planning of the human evnironment, communications and other aspects of life strongly influenced by design.

The founding group consisted of private citizens and public officials. Thir original intent was to establish a scientific institution which would use the personnel and resources of local universities to provide research and technical services for Rhode Island industry. When a feasibility study indicated that such an organization would not be self-supporting, the idea of a nationally-focused design research institute was developed. The founders believe that this unique organization, while serving a national market, will bring both direct and indirect benefits to industry in the Rhode Island area, much of which -- such as jewelry manufacturing -- is heavily design-oriented.

The institute is supported by research grants and contracts, and by initial operating grants from state governments, private industry and the economic development administration.

Functions: The functions of the Research and Design Institute are:

(1) To perform basic and applied design research for government, industry, institutions, foundations, and individuals.

(2) To provide experimental design and planning services to industry, institutions, government agencies and others in fields allied to the Institute's research programs.

(3) To provide a centralized national source of information on the design professions and on design research.

(4) To develop programs which enhance public and professional understanding of design.

(5) To develop programs of an educational nature which extend knowledge of design into many related professions and disciplines and which bring the knowledge of other fields to bear on design problems.

Name: Research Foundation of Kansas

Contact: Dr. C.E. Barthel, Jr.
Executive Director

Address: 708 KPL Tower
818 Kansas Avenue
Topeka, Kansas 66612

Background: The Research Foundation of Kansas was established by the 1963 Legislature as a nonprofit State body to provide for the promotion and conduct of both pure and applied research and the encouragement of the use of the results of research by the stimulation of improved institutional arrangements. It is governed by a Board of Directors, six of whom are appointed by the Governor and six are ex officio members. The staff consists of four professional and three secretarial persons.

The Research Foundation was established to (1) overview, stimulate and coordinate research in all areas of intellectual endeavor in the State of Kansas and (2) stimulate the use of the results of research for the benefit of the State and its people. It was established as a result of a study of a Governor's Economic Development Committee, which made a comprehensive study of the Kansas economy and recommended the establishment of such an organization.

Functions: Types of activities or programs include:

(1) Research Inventory of Kansas: A comprehensive inventory of the research activities and resources of the State of Kansas in all areas of intellectual endeavor is maintained on a continuing basis.

(2) Kansas Technical Services Program: The Research Foundation serves as the designated agency for the State of Kansas in this program which was developed and is financed in part as a result of the State Technical Services Act of 1965.

(3) Kansas Vocational Education Research Coordinating Unit: The Research Foundation is administering the activities of a Research Coordinating Unit to study occupational needs and to stimulate the development of vocational education curricula to meet these needs.

(4) Establishment of State Research Goals and Objectives.

(5) Coordination of Multiorganizational Research Activities.

(6) <u>Research Advisory Services</u>.

(7) <u>Public Awareness Program</u>.

(8) <u>Information and Referral Services</u>.

Name: Research Triangle-Foundation and Research Institute

Contact: Pearson Stewart, Vice President, Planning

Address: Research Triangle-Foundation and Research Institute
Hanes Building
Raleigh, North Carolina

Background: The Research Triangle Committee, Inc., later renamed the Research Triangle Foundation of North Carolina, was formed in 1956 by a small group of North Carolina leaders. The primary purpose of the group was to familiarize industrial and governmental research interests with the scientific resources and cultural advantages of the area and thereby to advance further the research resources of the area. The Research Triangle Institute and the Research Triangle Park were an outgrowth of the Foundation.

The Research Triangle Institute was established as a separate nonprofit corporation to provide contract research services to industry, government agencies, educational institutions, and foundations. Although it is closely allied with the three universities of the area -- Duke University, the University of North Carolina, and North Carolina State University -- the Institute performs research with its own full-time staff and its own facilities. It does, however, make use of the consulting assistance from the university faculty members.

The Research Triangle Park consists of 5,000 acres of land set aside for research and research-oriented manufacturing. Approximately 1,000 acres are geared for research alone and the remaining acreage is for research-oriented manufacturing.

Tenants of the Park now include:

Research Triangle Institute
Chemstrand Research Center
Forestry Sciences Laboratory of the U.S. Forest Service
American Association of Textile Chemists and Colorists
North Carolina Science and Technology Research Center
Triangle University's Computation Center
National Environmental Health Sciences Center of the U.S. Public Health Service
Data Processing Laboratory, National Center for Health Statistics of the U.S. Public Health Service
Technitiol, Inc.
International Business Machines, Inc.
Beaunit Fibers
Hercules, Inc.
Regional Education Laboratory

Name: St. Louis Research Council

Contact: Carroll A. Hochwalt, President and Director

Address: Pierre Laclede Building
7701 Forsyth Boulevard
St. Louis, Missouri 63105

Background: The St. Louis Research Council is a not-for-profit Missouri corporation formed for the purpose of developing and promoting the metropolitan St. Louis community as a major and nationally recognized scientific, educational and research center.

It was recognized that despite its excellent educational resources, the area's industrial activity did not fully reflect the national pattern of growth stimulated by technological innovation. The need for the universities and industries to work more closely together toward the area's growth in science and technology was clearly indicated.

Originally, a committee considered whether the community's technical creativity and ingenuity could be combined with organizational innovation to bring those resources more productively in play. The St. Louis Research Council was an outgrowth of these considerations.

Functions: Activities of the Council include:

(1) Coordinating and assisting the exchange of ideas and information on technological resources among the area's academic institutions, governmental agencies and industrial organizations.

(2) Obtaining and relaying information on opportunities for increased local participation in national programs of research or technology-based procurement.

(3) Encouraging and assisting St. Louis industry to acquire greater depth and breadth of new technologies and skills for product and process innovation and for future participation in advanced national programs of research and procurement.

(4) Advising and assisting the community's efforts to expand its technological capability and its economic base by attracting new technology-based operations to the area.

Since its inception in 1964, the Council has been instrumental in securing government research contracts with local universities and industries, the setting up of scientific and technical courses at the local universities for engineers and scientists of local industry, definition of technical problems of small business industries, and advising on consultants for the solution of such problems.

Name: Southern Interstate Nuclear Board

Contact: James B. Woodall, Jr., Deputy Director for Operations

Address: Suite 664
800 Peachtree Street, N.W.
Atlanta, Georgia

Background: The Southern Interstate Nuclear Board (SINB) was begun in 1961 upon the enactment of the compact by the required seven states. It was formed under the sponsorship of the Southern Governors' Conference.

Functions: The basic functions of the SINB include:

(1) Making available a centralized pool of specialized services for individual party states;

(2) Appraising technology utilization progress of the area;

(3) Helping to achieve parallel policies and statutes among the states in order to facilitate reciprocal recognition and services in science programs;

(4) Gathering and disseminating information;

(5) Providing a mechanism through which the party states may undertake cooperative ventures;

(6) Encouraging steps by the states to safeguard the public against possible radiological hazards.

Some of the accomplishments of the Southern Interstate Nuclear Board include the operating of a clearinghouse for nuclear data; sponsoring seminars, conferences, and symposia working to help state legislative research committees draft nuclear legislation, providing a collective voice for member states in dealing with nuclear energy matters at national as well as regional level; helping colleges and universities seeking grants for nuclear activities; providing guidance to states in developing science programs; and conducting studies on various pertinent subjects.

Name: Southern Regional Education Board

Contact: Dr. Winfred L. Godwin, Director

Address: 630 6th Street, N.W.
Atlanta, Georgia

Background: The Southern Regional Education Board, started in the late 1940's, was established by interstate compact as a public agency of 15 member states cooperating to improve higher education. The Board works directly with state governments, academic institutions,and other agencies concerned with the field of higher education.

Functions: The Board conducts cooperative programs across state lines aimed at providing better graduate, professional and technical education in the South. More specifically, it works with educators and government leaders to:

(1) Study the South's problems and needs in higher education,

(2) Find ways of solving these problems through region-wide cooperation,

(3) Administer student exchange programs between states and institutions,

(4) Serve as an information center on education activities in the region, and

(5) Provide consultant services to states and institutions on problems related to higher education.

Name: Spindletop Research

Address: Spindletop Research Center
Lexington, Kentucky 40505

Background: Spindletop Research was founded in 1961 by a special act of the Kentucky Legislature, as an institution to contribute to orderly economic growth, to stimulate industrial activity, and to encourage fuller use of the natural, human, and industrial resources of Kentucky, its region and the nation. Spindletop Research conducts research in the following areas:

(1) Techno-Economics,

(2) Systems Sciences,

(3) Physical Sciences, and

(4) Behavioral Sciences.

Spindletop maintains a close professional relationship with the University of Kentucky and both institutions have a policy of encouraging cooperation in the use of professional talents and physical facilities whenever and wherever possible. Faculty members at the University frequently contribute to Spindletop's projects on a consulting basis.

Name: Stanford Research Institute

Address: 333 Ravenswood Avenue
Palo Alto, California

Background: Stanford Research Institute was founded in 1946 by the Trustees of Stanford University at the request and with the support of a group of industrial leaders. The Institute is a separate nonprofit corporation governed by a Board of Directors elected by Stanford University Trustees. SRI conducts contract research in three research areas:

(1) Physical and Life Sciences,

(2) Engineering, and

(3) Economics and Management Research.

The primary purpose for founding SRI was to answer the need of business and industry for economic studies, economic planning, and the formal research team combination of scientific, technical, and economic personnel in attacking these problems.

Name: Tennessee Industrial Advisory Program
University of Tennessee

Address: Division of University Extension
Knoxville, Tennessee

Background: The University of Tennessee, through the Tennessee Industrial Advisory Program (TIRAS), has established a variety of means to aid local industry. Included in this program are:

(1) A referral service offering information on sources of expertise in the state;

(2) An information dissemination service;

(3) Field visits to industry; and

(4) New information on industrial engineering techniques being made available to industrial technical and personnel management.

These activities are being expanded under State Technical Services Program.

Name: Upper Midwest Research and Development Council

Contact: Thomas Anding, Executive Director

Address: 950 Federal Reserve Bank Building
Minneapolis, Minnesota 55402

Background: The Upper Midwest Research and Development Council is a nonprofit, educational and research corporation promoting the "civic and community welfare and commercial, economic, industrial, and social progress of the area...comprising the Ninth Federal Reserve District..." (including the full states of Minnesota, North and South Dakota, Montana, as well as Upper Michigan and Northwestern Wisconsin).

It was the concern of business and civic leaders throughout the region about the lagging economy of the area that led to the formation, in 1959, of the Council, which co-sponsored with the University of Minnesota, the Upper Midwest Economic Study, a project designed to examine existing economic conditions and to determine what could be done to accelerate economic growth.

Functions: The Council has encouraged has encouraged discussion and debate, throughout the district, of issues confronting agriculture, industry, education and urban development based on past and current research work. Research is a continuing function of the organization.

Accomplished programs of the Council include the Upper Midwest Economic Studies, 34 in all, covering various fields from agriculture to urban development. A supplement to the Studies, entitled Economic Growth and Adjustment in the Upper Midwest: 1960-1975, has been recently published.

The Council staff provides information and technical assistance to individuals, local and state agencies, business firms, community action groups, agricultural organizations, and civic groups.

In addition, the Council participates with numerous groups in a planning capacity and for liaison and coordination purposes.

An important part of the implementation of the Council's program is provided for the State Executive Committee set up within each of the states. These Executive Committees provide the Council a grass roots organization with up-to-date assessment of current problems, recommendations to the Council, and as a committee provide a voice influential in state and regional matters.

Name: Western Interstate Commission for High Education

Contact: Robert H. Kroepsch, Executive Director

Address: University East Campus
30th Street
Boulder, Colorado

Background: The Western Interstate Commission for Higher Education (WICHE) is a nonprofit, public agency created in 1953 by a compact including the 13 western states. This commission operates through group action -- advisory councils, committees, and associations that guide and direct the various programs. Among its overall objectives are to increase educational opportunities, expand the supply of specialized manpower, help colleges and universities improve their programs, and inform the public about the need of higher education.

Functions: To date, the primary focus of the group has been on certain aspects of educational opportunities and staff development in the health profession and in the helping services, as well as on the problems of management and organization of colleges and universities.

Current specific programs include:

(1) Student Exchange Program

(2) The Institute for College and University Self Study

(3) Nursing Council Program

(4) Medical Education Program in States without Medical Schools

(5) NIMH Mental Health Council Program

(6) Psychiatric Education for Physicians

(7) Corrections Project

(8) Special Education and Rehabilitation Program

Name: AEC Office of Industrial Cooperation

Contact: Ernest B. Tremmel, Director
Division of Industrial Participation

Address: Atomic Energy Commission
Washington, D.C.

Background: The Atomic Energy Commission, since its inception in 1946, has maintained a program for the dissemination of unclassified scientific and technical information. Recently, however, the AEC has established an Office of Industrial Cooperation. This is intended to encourage industrial usage of their information and will act as a go-between between the laboratory and industry.

Functions: Its functions are:

(1) To actively search for items of information and disseminate this information to industrial organizations;

(2) To be aware of the needs of particular sections of industry;

(3) To encourage the industrial participation program;

(4) To arrange industrial consultation and visits by industry representatives; and

(5) To work with such local organizations as now exist which will be suitable for its general purposes.

Name: Clearinghouse for Federal Scientific and Technical Information

Address: Springfield, Virginia 22151

Background: The Clearinghouse for Federal Scientific and Technical Information was established in 1964 as a result of a recommendation by the Federal Council for Science and Technology. Its principal services include:

(1) Sale of reports based on Government-sponsored R&D and sale of translations of foreign scientific and technical information;

(2) Literature searching services;

(3) A referral function;

(4) The compilation of bibliographies in many areas; and

(5) The review and dissemination of information of selected government research reports.

Name: NASA Office of Technology Utilization

Contact: Richard L. Lesher, Deputy Assistant Administrator
Technology Utilization

Address: National Aeronautics & Space Administration
Washington, D.C.

Background: The Office of Technology Utilization was established under provisions of the Space Act of 1958. Under this program new technology resulting from the agency's R&D programs will be identified, reported in industrial language, and communicated to civilian organizations. The Technology Utilization Program uses the resources of the Scientific and Technical Information Division which collects, abstracts and indexes, and brings together published and unpublished literature relating to aerospace activities.

Functions: The major functions of the Office are:

(1) Identification of industrially relevant new technology,

(2) Evaluation of that technology,

(3) Publication of new information, and

(4) Dissemination of the information.

NASA also operates regional dissemination centers to aid in these functions. Among the services offered by these centers are applications engineering, retrospective searching, selective dissemination, and other services.

Name: Office of State Technical Services
U.S. Department of Commerce

Contact: Paul J. Grogan, Director

Address: Main Commerce Building
Room 3800
Washington, D.C. 20230

Background: The State Technical Service Program was begun in September 1965. Included among the objectives are:

(1) The encouragement of the examining of technological and economic conditions in states and the development of plans to improve the local economy by the introduction and use of new science and technology.

(2) The identification of interstate, regional, or national problems or opportunities and the development of action programs to solve problems or capitalize on opportunities.

(3) The generation of an exchange of information among all states concerning their STS Program.

(4) To assist in resource development.

(5) To encourage science and technology as a force behind economic development.

(6) To study technology transfer in order to develop more positive means of obtaining the desired result.

(7) To increase the ability of scientists, engineers, and business and management personnel to acquire and use new S&T by programs of continuing education.

(8) To encourage state-university-industry cooperation, including inter-institutional and interstate relationships.

(9) To increase the ability of industry to gather and assimilate the pertinent aspects of the scientific and technical report literature for potential applications.

(10) To work with other governmental agencies, education institutions, and professional and technical societies in achieving the above objectives.

Name: Science Information Exchange

Contact: Monroe E. Freeman, Director

Address: 200 Madison National Bank Building
1780 M. Street, N.W.
Washington, D.C. 20086

Background: The Science Information Exchange is a component of the Smithsonian Institution and was started in 1949.

Functions: Its primary function was to serve R&D program managers in Federal agencies in order to:

(1) Help them avoid duplication,

(2) Establish priorities,

(3) Maintain balances among related research fields,

(4) Locate special research capabilities, and

(5) Perform other useful tasks.

Because of its mode of operation and the method of compiling information it performs a type of technology transfer program. It will tell any qualified scientist or engineer who is working in specific fields of interest. SIE collects only the records of research -- planned or in progress -- and does not receive progress reports, abstracts, or other forms of published research results.

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